NEW SERIES

# SELECTED

# **ESOURCES**ABSTRACTS



VOLUME 1, NUMBER 10A OCTOBER 1, 1968

# NEW SERIES

Selected Water Resources Abstracts is published semimonthly for the Water Resources Scientific Information Center (WRSIC) by the Clearinghouse for Federal Scientific and Technical Information (CFSTI) of the Bureau of Standards, U. S. Department of Commerce. It is available to Federal agencies, contractors, or grantees in water resources upon request to: Manager, Water Resources Scientific Information Center, Office of Water Resources Research, U. S. Department of the Interior, Washington, D. C. 20240.



# SELECTED

# WATER RESOURCES ABSTRACTS

'A Semimonthly Publication of the Water Resources Scientific Information Center, Office of Water Resources Research, U.S. Department of the Interior



VOLUME 1, NUMBER 10A OCTOBER 1, 1968

# UNITED STATES DEPARTMENT OF THE INTERIOR

STEWART L. UDALL, Secretary

OFFICE OF WATER RESOURCES RESEARCH
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# FOREWORD

Selected Water Resources Abstracts, a semimonthly journal, includes abstracts of current and earlier pertinent monographs, journal articles, reports, and other publication formats. The contents of these documents cover the water-related aspects of the life, physical, and social sciences as well as related engineering and legal aspects of the characteristics, conservation, control, use, or management of water. Each abstract includes a full bibliographical citation and a set of descriptors or identifers which are listed in the Water Resources Thesaurus (November 1966 edition). Each abstract entry is classified into ten fields and sixty groups similar to the water resources research categories established by the Committee on Water Resources Research of the Federal Council for Science and Technology.

Sufficient bibliographic information is given to enable readers to order the desired documents from local libraries or other sources. WRSIC is not presently prepared to furnish loan or retention copies of the publications announced.

Selected Water Resources Abstracts is designed to serve the scientific and technical information needs of scientists, engineers, and managers as one of several planned services of the Water Resources Scientific Information Center (WRSIC). The Center was established by the Secretary of the Interior and has been designated by the Federal Council for Science and Technology to serve the water resources community by improving the communication of water-related research results. The Center is pursuing this objective by coordinating and supplementing the existing scientific and technical information activities associated with active research and investigation program in water resources.

To provide WRSIC with input, selected organizations with active water resources research programs are supported as "centers of competence" responsible for selecting, abstracting, and indexing from the current and earlier pertinent literature in specified subject areas. Centers, and their subject coverage, now in operation are:

- Ground and surface water hydrology at the Water Resources Division of the U.S. Geological Survey, U.S. Department of the Interior.
- Metropolitan water resources management at the Center for Urban Studies of the University of Chicago.
- Eastern United States water law at the College of Law of the University of Florida.
- Policy models of water resources systems at the Department of Water Resources Engineering of Cornell University.
- Water resources economics at the Water Resources Research Institute of Rutgers University.
- Eutrophication at the Water Resources Center of the University of Wisconsin.
- Water resources of arid lands at the Office of Arid Lands Studies of the University of Arizona.

The input from these Centers, and from the 51 Water Resources Research Institutes administered under the Water Resources Research Act of 1964, as well as input from the grantees and contractors of the Office of Water Resources Research and other Federal water resources agencies with which the Center has agreements becomes the information base from which this journal is, and other information services will be, derived; these services include bibliographies, specialized indexes, literature searches, and state-of-the-art reviews.

Comments and suggestions concerning the contents and arrangement of this bulletin are welcome.

Water Resources Scientific
Information Center
Office of Water Resources Research
U.S. Department of the Interior
Washington, D. C. 20240

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# SELECTED WATER RESOURCES ABSTRACTS

## 02. WATER CYCLE

#### 2A. General

SOME RUNOFF PATTERNS IN A PROST AREA OF NORTHERN CANADA, Alberta Univ. Department of Geography, Edmon-

ton, Canada. A. Sommer, and E. S. Spence. Albertan Geograph, No 4, pp 60-64, 1968. 5 fig.

Descriptors: \*Permafrost, \*Melting, \*Frozen ground, Snowmelt, Glaciers, Precipitation (Atmospheric), Ice jams, \*Streamflow, Discharge (Water), Hydrographs, \*Surface-groundwater relationship. tionships, Fluctuation, Regime, International

Hydrological Decade, Temperature. Identifiers: \*Active layer, \*Dimensionless hydrographs, Ground thermal regime, \*Northwest Territories, Yellowknife River, \*Canada.

Dimensionless hydrographs of the Yellowknife River, N W T, Canada, show peak runoff in July. This is too late to be related directly to snowmelt, because mean monthly temperature first rises above freezing in May. The gradual rise and fall of discharge is not like the abrupt rise and fall associated with snowmelt regimes. The peak is too late to be explained by upstream ice blockage. Precipitation and discharge data for 1957-58 indicate that flows regime is not appreciably affected by the summer precipitation pattern; discharge varied less than 1 percent, while precipitation varied by 300 percent. High flows are in July, the hottest month, with a pattern similar to glacial-melt stream regime. The thermal regime in the active permafrost layers is suggested as the control of flow regime. Data are presented in dimensionless hydrographs, monthly precipitation graphs, monthly tem-perature graphs, and a graph of ground thermal regime. W68-00011

TEMPERATURE PROFILES IN WATER WELLS AS INDICATORS OF BEDROCK FRAC-

US Geological Survey Frank W. Trainer. US Geol Surv Prof Pap 600-B, pp B210-B214, 1968. 5 p, 3 fig, 2 ref.

Descriptors: \*Water temperature, Wells, Aquifers, \*Bedrock, New York, Geologic control, \*Fractures (Geology), Hydrogeology, Dolomite, Water circulation, Subsurface flow, Stratigraphy, Permeability, Groundwater movement

Identifiers: \*Temperature profiles, Fracture zones, Niagara County, Subsurface drainage, \*Interchange, Fluctuation.

Wells in the gently dipping Lockport Dolomite in Niagara County, New York, are characterized by downward flow of water from fractures in upper parts of the dolomite to deeper fracture zones. Temperature profiles for the wells can be used to determine the vertical distribution of water-bearing fractures because the profiles show inflections which mark levels of the fracture zones receiving the water. Areal distribution of fractures can be studied by correlation of the fracture zones from well to well. Representative temperature profiles are described and their use in interpretation of fracture distribution illustrated.

A COMPUTER MODEL FOR SOME BRANCHING-TYPE PHENOMENA IN

HYDROLOGY, Illinois Univ., Urbana. K. H. Liao, and A. E. Scheidegger. Bull of Int Ass of Sci Hydrol, Vol 13, No 1, pp 5-13, Feb 1968. 9 p, 3 fig, 2 tab, 6 ref.

Descriptors: \*Computer models, \*Porous media, Hydrologic properties, Dispersion, Channels, Groundwater movement, River basins, \*Statistical methods, Streamflow, Hydraulic properties, Flow nets, Drainage system.

Identifiers: \*Dispersion processes, \*Drainage network, Horton's law, Flow channels, Graphs, Fastran language.

Miscible displacement in a porous medium--a dispersive process which has been accounted for in several theories based mostly on statistical mechanics--is modeled on a computer. In hydrology, branching of flow lines occurs where channels either split or combine forming a network, such as in groundwater flow (splitting flow channels in a porous medium) and in the formation of a natural river network (combining, e.e., inverse branching of small rivers to form large rivers). Such phenomena can be treated by the statistics of topological bifurcating arborescences. It is shown how ensembles of arborescences can be generated on a computer and expectation values for observables can be calculated. In this way the laws of dispersion processes in flow through porous media and Horton's law of stream numbers in drainage basins are shown to be the outcome of very simple statistical assumptions. Tables of results are given for model flow through a porous medium and for model of river net. W68-00019

# 2B. Precipitation

RAINFALL GROUPINGS IN THE MIDDLE

EAST, H. L. Striem

Int Ass Sci Hydrol Bull, Vol 12, No 1, pp 59-64, Mar 1967. 6 p, 3 fig, 2 tab.

Descriptors: \*Rainfall disposition, Frequency analysis, \*Distribution patterns, \*River flow, Probable maximum precipitation, Meteorological data, Runoff, Rainfall-runoff relationships, Snowmelt, Intermittent streams, Hydrologic aspects, Discharge measurement, Water resources, Measurement, Peak discharge, Water year, Wet season. Identifiers: \*Middle East, Jerusalem.

When considering annual rainfalls over long periods, it seems there is no near symmetrical frequency distribution about an average value, but rather a series of maxima and minima. The rainfalls of Jerusalem, when analyzed for a period of 118 years, were found to be grouped into about five maxima. A river which is mainly nourished by runoff and snow-melting would have groups of annual discharges that correspond to the rainy seasons. Analysing the Jerusalem figures, it was found that the frequency distribution encountered had only a 15 percent probability when considering it to a case of a normal Gaussian distribution. The frequency series of the rainfall stations investigated did not have a reasonably homogeneous distribution, but lent itself to an interpretation as groupings of data with typical maxima and class intervals. This study may prove interesting to hydrologists and planners of water resources. W68-00297

HEAVY RAINS IN SOUTHEASTERN NEW MEXICO AND SOUTHWESTERN TEXAS, AUGUST 21-23, 1966, Weather Bureau, ESSA, El Paso, Texas; University of Texas; El Paso

of Texas, El Paso, Texas. Elden V. Jetton, and Calvin E. Woods. Monthly Weather Review, Vol 95, No 4, pp 221-226, April 1967. 6 p, 15 fig, 1 tab.

Descriptors: New Mexico, \*Rainfall intensity, Atmospheric pressure, Flood damage, Storm runoff, Synoptic analysis, Thunderstorms, Flash floods, \*Depth-area-duration analysis, Meteorological data, Cyclones, Weather patterns, Air temperature, Texas, Floods, Runoff, Fronts (Atmosphere), Precipitation (Atmospheric), \*Prepipitation ex-Identifiers: Stratosphere

During the period of August 21-23, 1966, heavy precipitation ranging up to 17 inches in some areas fell in southeastern New Mexico and southwestern Texas. Some of the possible factors contributing to the heavy rains are presented and the synoptic situation associated with the storm is analyzed. A confluent flow from the Gulf of Mexico and from the Pacific Ocean developed before the storm occurred. A cold front moving southward across the area along with the westward movement of a well-defined 700 m.b. trough appeared to be contributing factors to the heavy rains. Convergence existed at the 700 m.b. level surmounted by divergence at the 200 m.b. level just before the heaviest rainfall. Just prior to the onset of the heavy rains a wave in the westward stratopause flow moved across the area. This was shown by time sections of the stratospheric circulation taken at the White Sands Missile Range. It was suggested that variations in the stratospheric flow may play some part in the production of these rare, heavy rains.

# 2D. Evaporation and Transpiration

PAN EVAPORATION AND EVAPOTRANSPIRA-TION FROM CLIMATIC DATA,

Utah State Univ., Water Research Laboratory, Logan, Utah.

Jerald E. Christiansen.

ASCE Proc, J Irrig and Drainage, Vol 94, No IR2, Pap 5988, pp 243-265, June 1968. 23 p, 13 tab, 20 ref, 1 append.

Descriptors: Climatic data, \*Reservoir evaporation, Evaporation pans, \*Wind velocity, \*Evaportanspiration, Irrigation water, \*Reservoir operation, Mathematical models, \*Irrigation operation and maintenance, Meteorology, Reservoir

Identifiers: Land pans, \*Reservoir losses, Relative humidity

A formula is presented to estimate pan evaporation for a wide range of climatic conditions and latitudes. Pan evaporation data are useful in estimating losses from reservoirs and lakes, and for estimating evapotranspiration from agricultural crops using procedures which relate evapotrans-piration to pan evaporation. To estimate pan evaporation, the formula E = KRC has been developed in which E is evaporation, K is a dimensionless constant, R is extraterrestrial radiation, and C is a dimensionless coefficient related to the most readily available type of climatic parameters. The parameters used are temperature, wind velocity, relative humidity, sunshine percentage, and elevation. Tables are presented to simplify the application of the formula where electronic computers are not used. Three formulas for estimating evapotranspiration for several agricultural crops, using as the principal parameters either extrater-restrial radiation, pan evaporation, or measured incident radiation, together with climatic data are also presented. These formulas, developed from more limited data, may not be reliable for a wide range of climatic conditions and latitudes. W68-00021

A COMPARISON OF METHODS OF ESTIMATING POTENTIAL EVAPOTRANSPIRATION FROM CLIMATOLOGICAL DATA IN ARID AND SUBHUMID ENVIRONMENTS,

US Geological Survey.
R. W. Cruff, and T. H. Thompson. US Geological Survey, Water-Supply Paper 1839-M, 1967. 27 p, 5 fig, 10 tab, 19 ref.

Reliability

# Group 2D-Evaporation and Transpiration

Identifiers: \*Pans (Basins).

Comparison of potential evapotranspiration computed from climatological data of six empirical methods was made of 25 sites with a wide range of climatic conditions. This was done in the arid and subhumid parts of Arizona, California and Nevada over a calendar year and a 6 month period from May through October. The methods used were the Thornthwaite, Weather Bureau (a modification of the Penman method), Lowry-Johnson, Hamon, Blaney-Criddle and Lane. Lack of sufficient cli-matological data limited some methods to certain areas. Only the Weather Bureau method gave estimates that correlated with the adjusted pan evaporation where its use was possible. Low results were obtained with the Thornthwaite, Lowry-Johnson, and Hamon. Results with the Lane method agreed with pan evaporation at one site but were high at others. One data group was eliminated since adjusted pan evaporation in an arid environment was not a satisfactory standard to test the reliability of the methods. The most practical method was the Blaney-Criddle which agreed + 22 percent with adjusted pan evaporation. W68-00265

## 2E. Streamflow and Runoff

WATER-DELIVERY STUDY, PECOS RIVER, TEXAS, QUANTITY AND QUALITY, 1967, US Geological Survey

R. U. Grozier, H. R. Hejl, Jr., and C. H. Hembree.

Tex Water Develop Board Rep 76, 16 p, May 1968. 6 fig, 2 tab, 7 ref.

Descriptors: \*Water delivery, \*Texas, Water quality, Chemical analysis, Water supply, Discharge measurement, \*Chlorides, \*Diversion losses, Leakage, \*Water loss, Evapotranspiration, Seepage, Channel flow, River flow, Tamarisk,

Riparian water loss. Identifiers: Pecos River, Reaches, Water use, Seepage loss, Uniform flow, \*Channel loss.

A cooperative water-delivery study was made in April 1967 in a 188.4-mi reach of the Pecos River between Red Bluff Reservoir and Girvin, Texas, to determine changes in quality and quantity of a uniform flow of water. In the reach studied the river is a meandering 60-ft-wide stream, with long pools formed by gravel bars, rock outcrops, and low diversion dams. The channel was well saturated before the study and saltcedars along the stream were in full leaf so that losses were to both seepage and evapotranspiration. Discharge was measured at 25 sites and samples were collected for analysis at 29 sites. Water was released from the reservoir at a uniform rate of 547 cfs and 196.7 cfs loss was measured in the 127-mi reach below the dam. Loss ranged from .31 to 4.17 cfs/mi and averaged 1.8 cfs/mi. Saline inflow was .74 cfs from Salt Draw and .11 cfs from Sulphur Well. Chloride ranged from 760 ppm in the water released to 980 ppm near the end of the reach. From mile 127 to the end of the reach studied there was a net gain in flow of 8.2 cfs, although 3.6 cfs was lost between mile 150.2 and 158.2. Chloride content in this reach ranged from 3,140 to 6,340 ppm. Discharge measurements, chloride, and specific conductance at stream sites are tabulated, and discharge and chloride are shown on graph. W68-00006

# STATISTICAL SUMMARIES OF STREAM-GAGING STATION RECORDS, LOUISIANA, 1938-64,

US Geological Survey. M. F. Cook.

Louisiana Dep Public Works Basic Rec Rep No 1, 286 p, 1968. 4 fig, 2 tab, 14 ref.

Descriptors: \*Streamflow, \*Duration curves, Hydrographs, Frequency analysis, Flow charac-teristics, Peak discharge, Floods, Surface waters,

Low flow, Streams, Discharge (Water), Water management (Applied), Running Hydrologic data, Discharge measurement, Flow rates, Gaging stations, Stream gages, \*Louisiana, Average flow

Identifiers: Low flow frequency, Flow duration, Annual flow, High flow, 25-yr frequency, 50-yr frequency, Flood frequency, Water availability.

Statistical summaries of information from streamgaging stations in Louisiana, between 1938 and 1964, are presented and explained at length. Because the extensive calculations were done by electronic computer, the study is much more complete than past presentations, which included only a few streams. A brief description of each station is given, showing location, drainage area, and average discharge. Other pertinent data are in the 'Remarks' column. Flow-duration tabulation shows only complete yr of record. Summary data tables are used to construct flow-duration curves. For each gaging station a tabulation shows lowest mean discharge for each climatic yr for 11 selected time periods from 1 to 274 days. Low-flow-frequency curves are drawn from these calculations; high-flow frequency curves are also presented. (14 references) W68-00022

#### FLOW CHARACTERISTICS OF ALABAMA STREAMS--A BASIC DATA REPORT,

US Geological Survey, Water Resources Division. C. F. Hains

Geol Surv of Ala Circ 32, 382 p, 1968. tab, 1 append.

Descriptors: \*Data collections, \*Data processing, Gaging stations, \*Flow characteristics, Low flow, Hydrologic data, Statistical methods, Flow rates, Streamflow, Computers, Alabama, Base flow, Discharge measurement.

Identifiers: \*Statistical tables, \*Streamflow summaries, High flows, \*Flow duration, Basic data compilation, Mean discharge.

Three computer summaries of streamflow data for flow duration, low flows, and high flows in Alabama since the early part of the century are presented. Basic data are included for all gaging stations with 1 yr or more of records to Sept 30, 1963. Compilations are in downstream order. Statistical tables contain for each station: (1) Flow duration and flow distribution for specific periods, (2) summaries of low flow, and (3) summaries of the highest mean discharge, in cfs, for selected numbers of consecutive days in each water yr. An appendix lists all US Geological Survey Water Supply Papers containing records of daily discharge for streams in the State from 1901 to 1965. Gaged streams are listed alphabetically in the index W68-00025

# SUMMARY OF FLOODS IN THE UNITED STATES DURING 1962,

US Geological Survey J. O. Rostvedt.

US Geol Surv Water-Supply Pap 1820, 134 p, 1968. 49 fig, 40 tab, 14 ref.

Descriptors: \*Floods, \*Flood damage, Historic flood, \*Documentation, United States, Precipitation excess, Storms, Flash floods, Erosion, Regional analysis, Hydrography, Isohyets, Peak discharge, Snowmelt, Humidity, Temperature, Hydrographs, Rainfall-runoff relationships.

Identifiers: \*Meteorologic events, Physiographic characteristics, Peak stages, Flood frequency, \*Hydrologic events, Isohyetal maps.

The outstanding floods, nationwide, during 1962 are described. The most damaging floods occurred in Feb in southern Idaho and northern Nevada and Utah, and during late Feb and early Mar in Kentucky and in the Cumberland River basin, Tennessee. A combination of prolonged, low-intensity rains, moderate snowfall on low areas, a period of

high temperature, and ice glaze caused the Idaho, Nevada, and Utah floods. Damage to agricultural land and the heavily populated areas in Idaho alone totaled \$7 million. Two storms caused the Kentucky and Tennessee floods; rainfall exceeded 7 in. at places during the second storm. Damage in Kentucky totaled \$7 million. Recordbreaking snowmelt-floods occurred in southeastern South Dakota in Mar and Apr. Peak discharges on Floyd and Big Sioux Rivers were the greatest since 1881. Damage was \$4 million. May-June floods on tributaries of the Red River of the North caused \$5 million in damages in Minnesota. In western Florida, Sept floods caused \$3 million damage in 3 river basins. Damages from Sept floods in southern Arizona totaled \$3 million, mostly to farmland. Floods of lesser magnitude in 15 other areas are included in this annual summary. W68-00033

# USE OF DYE TRACERS TO COLLECT HYDROLOGIC DATA IN OREGON,

US Geological Survey.
D. D. Harris, and R. B. Sanderson.

Water Resources Bull, Vol 4, No 2, pp 51-68, June 1968. 18 p, 11 fig, 3 tab, 9 ref.

Descriptors: \*Hydraulics, \*Flow rates, \*Velocity, Streamflow, Dye releases, Oregon, \*Tracers, Dispersion, Discharge (Water), Discharge measurements, Surface waters, \*Flow characteristics, Fluorometry, Methodology, On-site data collections, Hydrologic data, River flow, Flow measurement.

Identifiers: \*Traveltimes, \*Fluorescent dye, \*Time-of-travel studies, Dye concentrations, Dye tracers, Travelrates, Rhodamine B dye.

Dye tracers have been used to collect data on 2,350 mi of streams in the Long Tom, Umpqua, Willamette, and John Day River basins in Oregon. In most of the studies, rhodamine B dye was dumped into the streams from bridges and was detected with a fluorometer at successive downstream sampling points a few mi apart. On the Long Tom River traveltimes from dye-tracer studies agreed reasonably well with the times computed using reach length divided by maximum and mean velocities. Travel rates in some streams varied in different reaches because of differences in gradient or because of inflow from large tributaries. These differences were most apparent during low-flow stages. Dye studies were also made in the 8,000-ft long Carmen-Smith power tunnel at discharges of 630 to 2,800 cfs. Discharges computed by the dye dilution and volume/traveltime method compared closely with powerplant ratings. The studies show that dye tracers may be used to (1) estimate traveltimes and travel rates of water, (2) determine discharge, and (3) determine dispersion characteristics of streams. Dye tracers also may be useful for tracing the movement of groundwater and discovering the sources of large springs. W68-00035

#### STOCHASTIC ANALYSIS OF DAILY RIVER FLOWS,

Pittsburgh Univ. Rafael G. Quimpo

ASCE Proc, J of Hydraul, Vol 94, No HY1, Paper 5719, pp 43-57, Jan 1968. 15 p, 2 fig, 6 tab, 1 append.

Descriptors: \*Hydraulics, \*River flow, \*Hydrographs, \*Stochastic process, Synthetic hydrology, \*Statistical models, Model studies, Natural flow, Streamflow forecasting, Sequential generation, Time series analysis, Analytical techniques, Markov processes

Identifiers: \*Streamflow components, \*Daily flows, Stochastic analysis, Spectral techniques of analysis, Powell River, Delaware River.

A stochastic analysis of river flow is presented as useful in simulation modeling to predict streamflow. To apply statistical techniques, it must be assumed that the series possess time-invariant properties. Daily flow may be divided into trend, oscillatory, and stochastic components. In an unregulated stream the trend component may be absent or can be subtracted out. The oscillatory component may be detected and isolated using spectral and Fourier analyses and Markov schemes fitted to the standardized residual series. In 5 rivers analyzed the stochastic or nondeterministic component of the time series is shown to follow the second order scheme. This seems justified because annual flows are considered to be random, in the absence of basin carryover, and monthly flows follow the firstorder autoregressive scheme. The study has shown that the primary variable, eta sub t (sequence of identically and independently distributed random variable), is highly important. In rivers, such as the Powell and Delaware, where the primary variable tributes a large percentage of the variance, the form of its true value must be known if a generated sequence of flows is to have any value. W68-00047

# TRAVEL RATES OF WATER FOR SELECTED STREAMS IN THE WILLAMETTE RIVER BASIN, OREGON,

US Geological Survey David D. Harris. US Geol Surv Hydrol Invest Atlas HA-273, 2 sheet, 1968. 1 map, 10 fig, 4 ref.

Descriptors: \*Streamflow, Stage-discharge relations, Stream gages, \*Hydrographs, River basins,
Oregon, Hydraulics, Channel flow, \*Columbia
River basin, Velocity, Tracers.

Identifiers: \*Travel rates, Low flow, Medium flow, High flow, \*Dye tracer, \*Time of travel.

Travel rates for high, medium, and low flows were determined by a fluorescent dye tracer for segments of five streams. Results are shown on a map. scale 1:500,000, and in 10 fig and a short text published as a 2-page hydrologic atlas. 5 of the fig consisting of 72 graphs illustrate travel rate in mi per hr and discharge at 72 sites on selected subreaches. The series of graphs can be used to determine the travel rate for any subreach for any discharge. Time of travel can be obtained by dividing the length of subreach by the travel rate. The other 5 fig consisting of 5 graphs show time of travel in hr for selected discharges at 5 index gaging stations on the stream segments studied. The graphs are useful for determination of time of travel between any 2 sites for the discharges indicated W68-00051

# DISCHARGE IN THE LOWER COLUMBIA RIVER BASIN, 1928-65,

US Geological Survey. Hollis M. Orem.

US Geol Surv Circ 550, 24 p, 1968. 4 fig, 12 tab, 4

Descriptors: \*Columbia River basin, River flow, Routing, Average flow, Discharge (Water), \*Columbia River, Streamflow, Natural flow, Oregon, Hydrologic data, Washington, Surface waters, Streamflow forecasting, Streams, Synthetic hydrology, Rivers, Gaging stations, Navigable

Identifiers: Monthly mean discharge, Ungaged areas, Observed flow, Annual flow.

Estimates of monthly and annual mean discharge for 5 ungaged sites in the lower Columbia River are tabulated for water yr 1928-65. One table lists flows that would have been measured by a gaging station; another gives the flows adjusted for diversions and storage in major reservoirs. The estimates were made by two methods. One method involves a detailed summation of flows from all gaged and ungaged areas with adjustment for precipitation on and evaporation from water surfaces and for travel time of the water from the Dalles and Salem, Oreg. gaging stations. In the second method, inflow below the 2 stations is estimated in 3 segments by correlation with a representative gaged stream. The resulting monthly mean flow data are considered to be accurate to 2 or 3%. W68-00075

#### **EVALUATION OF RUNOFF COEFFICIENTS** FROM SMALL NATURAL DRAINAGE AREAS, Kentucky Univ., Lexington.

Carlos Fix Miller. Research Rept 14, Kentucky Water Resrcs Inst, Lexington, 1968, 112 p, 25 fig, 14 tab, 36 ref.

Descriptors: \*Rational formula, \*Runoff coefficient, Peak discharge, \*Overland flow, \*Rainfall-runoff relationships, \*Surface runoff, Infiltration, Slopes, Vegetation effects, Soil surfaces, Precipitation excess, Time of concentration, Flood routing,

Culverts, Frequency analysis. Identifiers: Stanford Watershed Model.

The design flood peak for small drainage structures is usually estimated as the product of a runoff coefficient, a rainfall intensity, and a drainage area. The primary problem encountered in applying the method is selecting an appropriate runoff coefficient. Actually, the coefficient is the product of two components. The first relates peak overland flow rate to peak rainfall intensity. The second relates peak streamflow to peak overland flow. The Stan-ford Watershed Model was used to develop a set of curves to estimate the peak rate of overland flow from average watershed values of soil depth, soil permeability, overland slope, impervious area, and soil surface exposure. 50-year runoff coefficients for Lexington, Kentucky for 39 natural watersheds varied from 0.354 to 0.610. A second curve was developed for adjusting the coefficient for climatic differences. Multipliers ranged from 1.28 for the North Carolina mountains to 0.71 for Central California. A third curve for adjusting the coefficient for frequency showed multipliers ranging from 0.61 for the mean annual flood to 1.12 for the 1000-year flood. The overland flow runoff coefficient may be estimated as the product of the basic value and the two appropriate adjustment multipliers. W68-00187

# REGRESSION MODELS FOR PREDICTING ON-SITE RUNOFF FROM SHORT-DURATION CONVECTIVE STORMS,

USDA Southwest Watershed Research Center, Tucson, Ariz.

H. A. Schreiber, and D. R. Kincaid. Water Resources Res, Vol 3, No 2, pp 389-395, 1967. 7 p, 1 fig, 6 tab.

Descriptors: \*Regression analysis, Mathematical models, Infiltration, Thunderstorms, \*Storm runoff, On-site data collection, Forecasting, Runoff forecasting. Soil-water-plant relationships, Watersheds (Basins), Vegetative effects, Depth-area-duration analysis, Soil moisture, Arizona, Rainfall-runoff relationships, Hydrology, Equations \*Runoff

Identifiers: Walnut Gulch Watershed.

On-site runoff resulting from summer convective thunderstorms was studied in the Walnut Gulch Experimental Watershed, Tombstone, Ariz, using twelve 6 by 12 foot plots at two locations, based on five location-years of data from 34 storms. Average runoff increased as precipitation quantity increased, decreased as crown spread of vegetation increased, and decreased as antecedent soil moisture increased. In a stepwise multiple linear regression equation, these independent variables accounted for 72, 3, and 0.5 percent of the prediction variance respectively. For any one location year storm amount or intensity was always significant, crown spread was usually significant, and soil moisture was rarely significant. Soil moisture was never related significantly to runoff in simple correlations. Prediction equations of runoff were developed using total precipitation and storm intensity as independent variables. Crown spread of vegetation improved runoff prediction only 3 percent over the 72 percent that was obtained for total precipitation alone.

W68-00305

#### 2F. Groundwater

US GEOLOGICAL SURVEY TRACER STUDY, AMARGOSA DESERT, NYE COUNTY, NEVADA. PART 1-EXPLORATORY DRILLING, TRACER WELL CONSTRUCTION TESTING, AND PRELIMINARY AND FINDINGS.

US Geological Survey. Richard H. Johnston. US Geol Surv, 64 p, 1968. 7 fig, 14 tab, 5 ref.

Descriptors: Radioisotopes, Carbonate rocks, Permeability, Geologic formations, Aquifers, Groundwater movement, Drill holes, Borehole geophysics, Nevada, Cores, Tracers. Identifiers: Nuclide transport, \*Amargosa Desert,

\*Well construction, Lithology.

A USGS tracer study was made to determine the transport of nuclides in the water and particularly the rate of ground water movement through carbonate rocks underlying the Nevada Test Site and the Amargosa Desert. The high permeability carbonate rocks in this area constitute a drain connecting the several valleys with a discharge area of springs in the Amargosa Desert. Transport of radioactive nuclides through the carbonate rocks is controlled by the rate of ground warer movement and reactions between the nuclides and the rocks contacted by the water. An index map shows the location of 3 exploratory holes, 3 tracer holes, and 1 sample hole drilled for the tracer experiments. Graphics depict construction features of the holes and well, coring-time, and drilling time, as well as lithologic and geophysical logs of the exploratory holes. The aquifer which the tracer holes penetrate is confined above by alluvium of much lower permeability and bounded below by a limestone and shale unit of low permeability. Features of the geologic and hydraulic settings are briefly described. W68-00005

#### NONSTEADY-STATE FLOW IN PHREATIC AQUIFERS,

Hershel Weinberger. Water Resources Res, Vol 4, No 3, pp 567-571, June 1968. 3 p.

Descriptors: \*Groundwater movement, \*Hydraulics, Porous media, Darcy's law, Base flow, Flow measurement, Correlation analysis, \*Equations,

Aquifers, Resistance, Friction. Identifiers: Phreatic, Eulerian equation, Inertia, Steady state.

Equations for determining ground-water flow neglect the inertia of the liquid on the grounds that the frictional resistance of the porous medium rapidly damps all inertial motion. In order to determine if inertial terms are negligible, an analysis was made comparing solutions of equations containing inertial terms with solutions of equations assuming Darcial flow for an identical system. It was concluded that differences between flows calculated from equations assuming Darcian flow and the Eu-lerian equations that allow for the inertial terms were immeasurably small for practical values of aquifer constants. W68-00266

# CARBON 14 AGES AND FLOW RATES OF WATER IN CARRIZO SAND, ATASCOSA COUNTY, TEXAS,

University of Texas, Austin; U. S. Geological Survey, Austin.

J. Pearson, Jr., and D. E. White. Water Resources Res, Vol 3, No 1, pp 251-261, 1967. 11 p, 6 fig. 1 tab, 15 ref.

Descriptors: Geologic time, Geochemistry, Groundwater, \*Radioactive dating, Hydrologic data, Hydrology, Carbonates, Aquifers, Water analysis, \*Flow rates, Transmissivity, Permeability,

### Field 02—WATER CYCLE

## Group 2F—Groundwater

Porosity, Dating, Hydraulic gradient, Equations,

Hydrogeology. Identifiers: \*Carbon 14, Water age, Carrizo Sand, Geochronology.

Water samples from wells in the Eocene Carrizo Sand in Atascosa and adjacent counties, Texas, were dated by determination of carbon 14 content in the carbonate dissolved in the water. The carbon 14 is derived from plant produced carbon dioxide in the soil of the recharge area and is usually diluted by carbon 14 free carbonate dissolved from limestone in the soil and aquifer. Corrections for these factors can be made by using ratios of carbon 13/carbon 12 isotopes and the complete carbonate chemistry of the water. The ages of the water samples ranged from 0 years at the outcrop to 27,000 years 35 miles downdrop. Based on these ages the velocities were 8 feet per year 10 miles from the outcrop and 5.3 feet per year at 31 miles. The results from the carbon 14 studies were analogous to results calculated from available hydrologic data. W68-00294

## 2G. Water in Soils

PREDICTION OF THE EFFECT OF MIXED-SALT SOLUTIONS ON SOIL HYDRAULIC CONDUCTIVITY,

US Salinity Laboratory, Riverside, California.

B. L. McNeal.

Soil Sci Soc Amer Proc, Vol 32, No 2, pp 190-193, March-April 1968. 4 p, 2 fig, 1 tab.

Descriptors: Reliability, Correlation analysis, Mathematical studies, \*Hydraulic conductivity, Saturated soils, \*Saline soils, Soil types, Alkaline soils, Permeability, Salts, Montmorillonite, Soil texture, Clay minerals, Mineralogy, Clays, Probability. Identifiers: U. S. Salinity Laboratory, Riverside, Calif., Clay swelling, Cation distribution.

Existence of a rather good inverse relation between hydraulic conductivity and the swelling of extracted soil clays in comparable solutions suggested that clay swelling might provide an index for relating soil hydraulic conductivity to solution composition. A procedure for predicting the hydraulic conductivity of soils in the presence of a wide range of mixed-salt solutions is presented. Calculated interlayer swelling values for soil montmorillonite serve as a frame of reference for the predictions. A simplified domain model for characterizing the exchangeable-cation distribution on sodium-calcium montmorillonites was used to obtain the swelling values. Agreement between the calculated and experimental values of hydraulic conductivity was good, with an average difference between the two sets of values of .002 and a standard deviation between the sets of .053. A monogram is presented which provides swelling factors for various combinations of ESP and salt concentration.

W68-00261

# THE RELATIONSHIP BETWEEN GEOMORPHOLOGY AND LAND USE IN THE MEDITERRANEAN COASTAL LITTORAL OF THE UAR,

Desert Institute, Cairo; University of Ain Shams, Alexandria, UAR

M. A. Hammad, M. A. Abdel Salam, and H. Hamdi

J Soil Sci United Arab Republic, Vol 7, No. 1, pp 1-14, 1967, 14 p, 2 fig, 2 maps, 1 tab, 16 ref.

Descriptors: \*Geomorphology, \*Coastal plains, Semiarid climates, Soil formation, Aerial photography, Soil horizons, Soil structure, Caliche, Soil classifications, Soil profiles, Calcium compounds, Calcareous soils, Drainage systems, \*Littoral, \*Land use, Arid lands, Mapping, Topography, Soil texture, Sampling, Lime, Gypsum, Salts. Identifiers: United Arab Republic.

Field studies were conducted by the use of topo-graphic maps, scale and aerial contact prints. The

morphological features were recorded through color, texture, structure, consistency, symptoms of development including depth of profile and the hardness of lime accumulation horizon. Samples were collected for laboratory analysis where particle size distribution, salt content, soil reaction, lime and gypsum contents were determined. In the arid regions the soil profiles with their consequent horizons reflected directly the geomorphic processes. An effort was made to classify the soils within geomorphic units as a change in the landform almost indicates a corresponding change in the soil. The only symptom of profile development was in the formation of a calcic horizon. The data indicated the prevalence of semi-arid conditions acting on a calcareous parent material confined to the various geomorphic units of the western Mediterranean coastal region of the U.A.R. Since each geomorphological unit comprised certain soils which were different from those of the other units, different types of land utilization would be adopted. W68-00264

# GENESIS AND RELATIVE WEATHERING INTENSITY STUDIES IN THREE SEMIARID SOILS.

University of Arizona, Tucson. B. R. Smith, and S. W. Buol. Soil Sci Soc Amer Proc, Vol 32, No 2, pp 261-265, Mar-Apr 1968. 5 p, 2 tab, 21 ref.

Descriptors: Soil chemical properties, \*Soil formation, Semiarid climates, Soil physical properties, X-ray spectroscopy, Molecular ratio, \*Weathering, Soil types, Loam, Soil investigations, Sampling, Vegetation, \*Clays, Calcareous soils, \*Clay minerals, Molecular structure, Soil analysis, \*Soil profiles, Translocation, Arid climates. Identifiers: \*Illuviation, \*Aridisols.

There is disagreement among pedologists as to the role of clay illuviation and clay formation in situ in the development of argillic horizons in arid and semiarid regions. Three soil profiles sampled in Santa Cruz and Pima counties, were selected for this study. Two of the soils contained argillic horizons in which the fine clay (less than 2 microns)/coarse clay (2-0.2 microns) ratio has higher than in other horizons. X-ray spectrographic analysis of the silt fraction was used to obtain CaO/ZrO sub 2 molecular ratios. These molecular ratios were used to estimate the relative weathering intensities within the 3 profiles. It was concluded that maximum weathering occurred in the surface horizons and that the argillic horizons were at least partially the result of translocation of clay from the A horizon; however, the argillic horizons in both profiles were more strongly weathered than the underlying material, indicating that some of the clay had formed in situ. Evidence of illuvial clay was indicated by a few clay skins, but these features were destroyed by wetting and drying in most cases.

## THE EFFECT OF SOIL PHYSICAL CONDITIONS ON RECLAMATION OF SALINE LAND, Irrigation Research Laboratory, C.S.I.R.O., Griffith, N.S.W., Australia. T. Talsma.

Int Comm Irrig and Drainage, Sixth Congress, Vol 2, Question 19: 19.83-19.91, 1966, 9 p, 4 fig.

Descriptors: Soil properties, \*Water table, \*Saline soils, \*Capillary conductivity, Moisture uptake, Soil tolerance, Soil profiles, Clays, Model studies, Physical properties, Mechanism, Piezometry, \*Salinity, Land reclamation, Soil physical properties, Leaching, Diffusion, Evaporation, Ground-water, Osmosis, Root zone, Loam.

Identifiers: Salinization, Steady state, Salinity con-

Permanent reclamation of saline land depends on a proper understanding of the mechanism of salt movement through the soil profile. Soil properties that are important in understanding the salinization and leaching mechanisms are illustrated by field data obtained on chloride transfer. The main soil property, involved in the steady state transfer of moisture and salt to the soil surface, is the capillary conductivity-moisture suction relationship. At equal evaporation rates, it was found that a loam soil could maintain moisture movement from a water table at considerably greater depth than the clay soil. For both soils a small increase in watertable depth reduced evaporation and salinization considerably at high evaporation rates, while at lower evaporation rates it was necessary to reduce the water table over a much greater depth interval for an equal salinity control. Proposed models describing the leaching process are discussed together with analyses of leaching experiments. W68-00309

## 2I. Water in Plants

# COMPETITIVE RESPONSE TO MOISTURE STRESS OF A WINTER ANNUAL OF THE SONORAN DESERT,

Ohio State University, Columbus, Ohio. Lionel G. Klikoff. Amer Midland Natur, Vol 75, No 2, pp 383-391, April 1966. 9 p, 7 fig, 2 tab.

Descriptors: \*Moisture stress, Environmental effects, Germination, \*Plant populations, Soil temperature, Air temperature, Precipitation, Soil moisture, \*Growth stages, \*Desert plants, \*Phenology, Density, Flowering, \*Productivity, Plant growth, Turgidity, Irrigation, Dew, Humidity, Soil-water-plant relationships, Rainfall. Identifiers: Sonoran Desert, Survival, Fruiting,

\*Genetic variability.

The growth and development of plants in the desert are determined in a large measure by the availability of water which is partially dependent upon the density of plants. A small winter annual of the Sonoran Desert, Plantago insularis variety fastigata, was used to evaluate the density-dependent aspects of water stress. Three different plant densities, each of which was subjected to three degrees of moisture stress, were studied in all combinations. Phenological development was studied by noting the times of first flowering, maximum fruiting and total death in each of the permanent quadrats. The rate of decline of the populations as measured by the percentage of living plants was affected by the interaction of initial density with relation to moisture stress. Within the range of moisture stresses, the slowest decline occurred at low moisture stress. Genetic variability seems to play a role in the competitive response of the population to water stress. W68-00260

#### ECOTYPIC VARIATION IN LARREA DIVAR-ICATA,

University of Texas, Austin. T. W. Yang.

Amer J Bot, Vol 54, No 8, pp 1041-1044, Sept 1967. 4 p, 2 fig, 2 tab.

Descriptors: Plant populations, Plant-soil-water relationships, On-site data collections, Environmental effects, Water requirements, New Mexico, Correlation analysis, Environmental gradient, Germination, \*Ecotypes, \*Variability, Plant growth, Thermocline, Growth rates, Resistance, Seeds, Arizona, Texas, California.

Identifiers: \*Creosotebush, Chihuahuan Desert, Sonoran Desert.

Seeds of creosotebush (Larrea divaricata) were collected from populations in California, Arizona, New Mexico, and Texas and grown under uniform experimental environments to determine ecotypic differences in rate functions. The populations sampled in Arizona, New Mexico, and Texas all lie in the Chihuahuan Desert while those from California lie in the Sonoran Desert. The Sonoran Desert ecotype was characterized by a taller, more erect and more open growth form, more slender and less in-

# Chemical Processes—Group 2K

curved leaflets, slower germination rate, slower initial growth rate of the seedling, less tolerance for low temperature, and greater tolerance for low moisture when compared to the Chihuahuan Desert ecotype. W68-00267

LEAF RESISTANCE TO WATER VAPOR TRANSFER IN SUCCULENT PLANTS: EFFECT OF THERMOPERIOD,

University of California, Riverside.

Irwin P. Ting, Margaret-Lee Dean Thompson, and W. M. Dugger, Jr.

Amer J Bot, Vol 54, No 2, pp 245-251, Feb 1967. 7

p, 7 fig, 31 ref.

Descriptors: \*Transpiration, \*Water vapor, \*Ther-Light, Biorhythms, moperiodism, Fluctuations \*Photoperiodism, Temperature, Diurnal, Photo action, Photosynthesis, Nocturnal, Leaves, Plant physiology, Stomata, Osmosis, Microenvironment, Resistance, Hygrometry. Identifiers: \*Succulent plants.

An investigation was conducted at Riverside, California, to ascertain the diurnal fluctuation of leaf resistance to water vapor transfer by means of a resistance hygrometer and to determine the effect of thermoperiod and photoperiod on leaf resistance. Kalanchoe blossfeldiana was used as the experimental plant in the study. On 8 hour photoperiods and a thermoperiodic regime of 26 C in light and 21 C in dark, leaf resistance to water vapor transfer was low in the light and high in the dark. When temperatures were high in the light and low in the dark, an apparent resistance reversal was observed, i.e. high resistance in the light and low in the dark. This indicated night stomatal opening was measured in the dark as well as in the light. The results indicated CO sub 2 uptake in both light and dark with the dark rate 71% of the light rate. Leaf resistances were generally higher than those reported for nonsucculent plants. It was concluded that the photoperiod response effects of dark CO sub 2 fixation were probably not due to leaf-resistance changes and, therefore, not due to stomatal aperture changes. W68-00281

AUSTRALIAN DESERT MICE: INDEPENDENCE OF EXOGENOUS WATER,
Pomona College, Claremont, Calif.; Monash University, Clayton, Victoria, Australia.
Richard E. MacMillen, and Anthony K. Lee.
Science, Vol 158, No 3799, pp 383-385, Oct 1967.
3 p, 1 fig, 2 tab.

Descriptors: \*Xerophilic animals, \*Water requirements, Laboratory tests, Environmental effects, Osmotic pressure, Rodents, \*Animal metabolism, Animal physiology, Arid climates, Urine, Water balance, Flexibility, Chemical analysis, Seeds, Water loss, Liquid wastes.

Identifiers: Australia, Survival, Adaptation, Alice Springs, N.T.

The Australian desert rodents inhabit some of the hottest, driest regions on earth. The water economies of the Australian hopping mice, Notomys alexis and Notomys cervinus and the sandy inland mouse, Leggadina hermannsburgensis were stu-died. The rodents were from a region of less than 10 inches of annual precipitation and were collected at the end of a severe drought which had lasted for 10 years. They were fed excess of bird seed for food. Urine, blood and feces were collected and analyzed for water content and the concentrations of urea in whole blood and urine were determined. Results showed that all three species were independent of exogenous water and that they concentrate urine to extreme degrees. The kidneys are the significant site of water concentration. The rodents owe their independence from drinking water to extreme renal capacities for concentrating urine and to a reduced output of water in the feces. This capacity allows tham to survive in areas of low rainfall and humidity without needing to take in water from any exterior source.

W68-00284

## 2J. Erosion and Sedimentation

FALL VELOCITY AS AFFECTED BY FINE MATERIAL CONCENTRATIONS,

South Dakota State Univ., Brookings. G. R. Algar.

Descriptors: \*Sediment transport, \*Sediment distribution spheres, \*Velocity, Transition flow, Turbulent flow, Soil classification, \*Suspended load, Settling velocity, \*Bed load, Dunes.

The vertical distribution, transportation, and deposition of sediment were related to the terminal fall velocity of the sediment particles. The terminal fall velocity depended upon many variables, including type of fluid, type of flow, and variables of boundary geometry. Effects were studied of various concentrations of fine materials on the apparent resistance to motion of larger particles and the relationship of this apparent resistance to the fall velocity of larger particles. Glass and steel spheres falling in various concentrations of water and bentonite were studied through the range of concentrations between 0 and 50,000 ppm. The fall velocity appeared to be maximum at a concentration of about 30,000 ppm with velocities decreasing with concentrations on either side of the maximum. This phenomenon, along with other factors, can be related to sediment movement of stream hed material. W68-00184

# THROUGHFLOW, OVERLAND FLOW AND

EROSION, Cambridge Univ. M. J. Kirkby, and R. J. Chorley. Bulletin International Assoc Sci Hydrol, Vol 12, No 3, pp 5-21, Sept 1967. 17 p, 7 fig, 16 ref.

Descriptors: \*Overland flow, \*Erosion, \*Infiltra-tion, \*Model studies, Surface runoff, Saturated flow, Unsaturated flow, Channel erosion, Hydrographs, Rainfall-runoff relationships, Permeability, Watersheds (Basins), Clays, Shales, Time series analysis, Flow rates. Identifiers: Throughflow

Different mathematical models have been used to the study of water and its behavior in arid regions. With the Horton infiltration approach to surface runoff and erosion, it has become apparent that this overland flow model represents only a specialized end-member of a series of models. The Horton model is most appropriate in arid and semi-arid clay or shale badlands. This model of overland flow is most dominant on unvegetated slopes in arid regions where the thin soil cover is hydrologically similar to the unweathered bedrock. The throughflow model is more appropriate to humid vegetated regions where a generally thick soil cover temporarily stores an appreciable amount of rainfall as soil moisture which plays a significant role in the basin hydrological cycle. Channel initiation or extension was found to take place where overland flow occurs and would take place preferentially in the above locations adjacent to existing channels.

#### DISTINCTIVE BRINES IN GREAT SALT LAKE, UTAH,

Utah Geological and Mineralogical Survey. A. H. Handy.

U S Geological Survey, Professional Paper 575-B, pp 225-227, 1967. 3 p, 2 fig.

Descriptors: \*Great Salt Lake, \*Dissolved solids, Potassium, Sodium, Chlorides, Distribution patterns, Sampling, Density, Data collections, Chemical analysis, Economic feasibility, Brines. Identifiers: Lithium.

Prior to construction of a causeway in Great Salt Lake, Utah, in 1957, it was assumed dissolved elements were in a uniform distribution due to the action of winds and currents in the shallow depth of the Lake. In 1965 samples were collected from 26 sites at varying depths on both sides of the porous causeway. By plotting density against concentra-tions of potassium and lithium at least four distinct types of brine were determined. Brine north of the causeway had a density of about 1.22 g/ml. The potassium concentration exceeded 6,700 ppm and lithium exceeded 60 ppm. Brine south of the causeway had a density of 1.17 g/ml. The potassium concentration was less than 5,000 ppm and lithium was 41 ppm or less. Areas south of the causeway which had a greater depth were found to have higher concentrations of potassium and lithium. These were unaffected by surface inflow and mixing by winds and currents. W68-00302

# SEDIMENTATION RESEARCH NEEDS IN SEMIARID REGIONS,

USDA Southwest Watershed Research Center, Tucson, Ariz. Soil and Water Conservation Research Service, Tucson, Ariz.

Kenneth G. Renard, and Robert B. Hickok. Amer Soc Civil Eng J, Vol 93, No HY1, Proc Paper 5060, Jan 1967. 15 p, 10 fig, 26 ref.

Descriptors: \*Sedimentation, \*Watershed management, \*Deposition (Sediments), Transport deple-tion, Community development, Withdrawal, Semiarid climates, Alluvial channels, Degradation (Stream), Reservoir storage, Sediment transport, Hydrologic data, Channel improvement, Bank erosion, Gully erosion, Floodways, Streams, Energy, Conservation, Erosion. Identifiers: Piping.

It is difficult to plan, design, construct, or maintain watershed conservation and control measures without becoming involved in some aspect of sedimentation. Most reservoirs built require estimates of the probable rate of storage loss due to sediment deposition. Total sediment and its pattern of deposition is especially important in semiarid areas. The balance of most alluvial channels is very delicate and a change of a single variable upsets the normal pattern with the long-time trend being degradation. The primary problem in the prevention of losses caused by erosion and sediment deposits from upstream watershed lands is to limit the movement of sediments from their sources. Little work has been done with sedimentation problems on upstream watersheds. The largest part of the work has been confined to studies of sediment transport in larger streams and reservoir sedimentation studies in larger reservoirs. Since water is the principal transporter as well as the primary source of energy causing the detachment of sedi-ment, it is imperative that adequate hydrologic measurements be considered in the planning of sedimentation research, and that better means to measure the many phases of sedimentation, from the detachment to the transportation and final deposition, be developed. W68-00310

# 2K. Chemical Processes

QUALITY OF SURFACE WATERS OF THE UNITED STATES 1960, PARTS 1 AND 2-NORTH ATLANTIC SLOPE BASINS AND SOUTH ATLANTIC SLOPE AND EASTERN GULF OF MEXICO BASINS,

US Geological Survey.

S. K. Love. US Geol Surv-Water-Supply Pap 1741, 418 p, 1968. 1 fig.

Descriptors: \*Water quality, \*Chemical analysis, \*Sediment transport, Sediment load, Sediment discharge, \*Water temperature, Data collections, Hydrologic data, United States. Identifiers: \*Chemical analysis (Water), Chemical

quality, Surface-water quality, Atlantic slope

#### Field 02—WATER CYCLE

# **Group 2K—Chemical Processes**

Chemical-quality and sediment data collected by the US Geological Survey in the 1960 water year are presented. Included are analyses of water from 116 daily and monthly stations, temperature data for 112 stations, and suspended-sediment data from 38 stations. Data are reported for streams draining into the Atlantic Ocean and eastern part of the Gulf of Mexico (Maine to eastern Mississippi). Similar data are presented for the remainder of the 48 conterminous states in 4 other volumes. In addition to data tables, discussions are included on the significance of mineral constituents, sediment sources, and character of sediment transport. W68-00009

GROUND WATER CHEMISTRY AS A TOOL FOR GEOLOGIC INVESTIGATIONS IN THE SOUTHEASTERN PIEDMONT,

Furman Univ., Department of Geology, Greenville, SC, North Carolina Univ., Department of Geology, Chapel Hill.

Van Price, and P. C. Ragland. Southeastern Geol, Vol 9, No 1, pp 21-38, Apr 1968. 18 p, 5 fig, 4 tab, 20 ref, 1 append.

Descriptors: \*Geochemistry, \*Groundwater, \*Geologic investigations, \*Mineralogy, Water properties, Spectrophotometry, Standards, North Carolina, Lithification, Analytical techniques, Wells, Springs, Water quality, Dissolved solids, Geologic control, Sodium, Water pollution Geologic control, Sodium, Water pollution sources, Geologic mapping, \*Water chemistry. Identifiers: \*Mineral prospecting, Graphics, Mafic terranes, \*Piedmont area, Chemical weathering.

Geochemical techniques were used to determine whether chemical studies of groundwater samples can be used in geologic mapping and mineral prospecting in the southeastern Piedmont. In this area direct observations are often impossible due to the lack of rock outcrops. Water samples were col-lected from random wells and a few springs and streams, and were analyzed by atomic absorption spectrophotometry. Results are presented in tables, logarithmic plots, and a map showing relative zinc concentrations; they show a validity for certain rock types, but results are of little or no significance in others. The main conclusions are: (1) This technique can be useful adjunct to geologic mapping; (2) favorable results in lithium detection suggest further research into use of groundwater prospecting for certain less common elements, such as boron, lithium, and zinc; (3) magnesium and strontium show a strong covariance, both increasing in value in more mafic terranes; and (4) anomalous chemistry, such as sodium concentration, can be related to water pollution sources. The report lists 25 sampling sites. W68- $\theta$ 0027

# CHEMICAL CHARACTERISTICS OF BULK PRECIPITATION IN THE MOJAVE DESERT REGION, CALIFORNIA,

US Geological Survey.

U S Geol Survey, Prof Paper 575-C, pp 222-227, 1967. 6 p, 2 fig, 2 tab.

Descriptors: \*Chemistry of precipitation, \*Deserts, Dissolved solids, \*Fallout, Rain gages, Electrical conductance, Rain, \*Dusts, Salts, Calcium carbonate, California. Identifiers: Bulk precipitation, Mohave Desert.

Determinations of chemical composition were made on 39 samples of bulk precipitation from 12 locations in the Mojave Desert region, Calif. Bulk precipitation is defined as the solution that results when melting snow or rain falling on the land sur-face, whether in its natural state or modified by man, collects and incorporates the products of dry fall-out. Collections were made in rain gages with a layer of transformer oil to prevent evaporation. The samples were analyzed by methods standard in the U.S.G.S. with the exception of chloride which was determined by a more sensitive method. Specific conductance ranged from 8.9 to 823 micromhos and varied inversely with quantities of rain. The chemical composition of the samples was strikingly similar to analyses made at Menlo Park, Calif, a totally different environment. Dust that contained saline materials appeared to have governed the composition and concentration of bulk precipitation. Although bulk precipitation varied from place to place and with time it was mainly a calcium bicarbonate type as is most precipitation. W68-00299

## 03. WATER SUPPLY **AUGMENTATION** AND CONSERVATION

## 3A. Saline Water Conversion

VACUUM-FREEZING VAPOR-COMPRESSION DESALTING PROCESS,

Colt Industries Inc., Beloit, Wis R. Consie, D. Emmermann, and J. Fraser. U S Office of Saline Water Res and Develop Progr Rep No 295, 99 p, 1968. 23 fig, 1 append

\*Vapor compression distillation, \*Desalination processes, Pilot plants, Sea water, Performance, Design data, Pumps, Cost analysis, Freezing, Desalination plants, Bemineralization. Identifiers: \*Vacuum freezing, \*Progress report, Power rate, Tables, Equipment (Plant).

Summaries of monthly activities and evaluation of performance data from Feb 1965 through Mar 1967 are presented in this progress report on the Vacuum-Freezing Vapor-Compression Process (VFVC). The first phase of activity centered on the assembly of a 60,000 gpd VFVC pilot plant. The second phase demonstrated a production capability of nearly twice the original specification and a minimum power requirement of 53 KW-HR/1,000 gal. The plant description covers the hydroconverter, counterwasher, heat exchanger, deaerator, pumping, and controls. 2 types of primary compressors and 2 carry over separators were tested and evaluated during the entire contract period. A component analysis on vapor compressor, carryover separator, freezer, melter, counterwasher, pumps, motors, and valves is included. An appendix briefly outlines plant design and operating criteria on sea water desalting plants for use in calculating the cost of fresh water produced by a large-scale desalting module. W68-00078

# DEVELOPMENT OF ELECTROCHEMICAL ION EXCHANGE MATERIALS AND TECHNIQUES FOR DESALTING WATER,

Marquardt Corp A. W. Venolia, and A. M. Johnson.

U S Office of Saline Water Res and Develop Progr Rep No 300, 80 p, Jan 1968. 32 fig, 10 tab, 20 ref,

Descriptors: \*Desalination, \*Ion exchange, \*Electrochemistry, Carbon, Coatings, Brackish water, Separation techniques, Desalination apparatus,

Heat exchangers, Thermodynamics. Identifiers: Thermosorb, Electrosorb, Cyclic regeneration, Cost factor differential equations, Spectrographic analysis, Polymerization.

The thermosorb and electrosorb methods of desalting, and the present status of the thermosorb process are described. Both approaches to desalination depend upon combined electrochemical ion exchange effects. In this exchange, ions are reversibly sorbed from solution upon 'clectrods' made of suitably pretreated carbons. These carbon sorbents are cyclically regenerated by the use of either thermal or electric energy. Brackish water processing costs of approximately \$.20 per thousand gal, sea water costs near \$1.60 per thousand gal can be anticipated for plants of 100,000 gal per day. For the thermosorb process, preliminary evaluation of potential performance is underway, but no firm analyses yet have been made. In the electrosorb process, although its feasibility is not firmly established, the present sorbent materials can be used to achieve satisfactory per-formance levels. This has been demonstrated by extensive testing with sodium chloride systems.

NUCLEATION AND GROWTH OF ICE CRYSTALS,

North American Rockwell Corp, Rocketdyne Div. G. R. Schneider, and J. Farrar. U S Office of Saline Water Res and Develop Progr Rep 292, 37 p, Jan 1968. 7 illus, 5 tab, 26 ref.

Descriptors: \*Crystal growth, \*Nucleation, \*Ice, Brines, Slurries, \*Desalination apparatus, Particle size, \*Hydrates, \*Desalination processes, Crystallography, Hydrate processes, Phase diagrams, Melting, Desalination, Molecular structure, Freezing, Sodium chloride, Cryogenics, Thermodynam-

Identifiers: Analyzer, Particle counter, Particle analyzer, Iso-butane, Butadiene, Ice-brine slurries, Hydrocarbons, Ice crystals.

In studies of crystal growth and nucleation in icebrine slurries, a particle-size analyzer was obtained and a freeze-crystallizer setup was constructed for experiments attempting to form hydrates from nbutane, iso-butylene, 1-butene, cis-2-butene, and butadiene. Test results were negative as none of these species could be made to form hydrates. A number of commercially available particle-size analyzers were considered for use with ice slurries, and several techniques of particle sizing and counting were examined. The phase diagram for the isobutane-water-NaCl system was determined for pure water and for solutions containing 1.10 and 9.93 weight % NaCl. Considering the size of the iso-butane molecule and the value of n determined, iso-butane, which did form a hydrate, is undoubtedly a structure II hydrate. Appropriate schematics are included. W68-00093

# 3B. Water Yield Improvement

PATTERNS OF RUNOFF IN THE WILLAMETTE BASIN, OREGON, US Geological Survey.

Eugene A. Oster.

US Geol Survey Hydrol Inv Atlas HA-274, 1 p, 1968. I map, 2 fig, disc.

Descriptors: Oregon, \*Columbia River basin, \*Hydrographs, \*Natural flow, \*Areal, Snowmelt, Low flow, Average flow, Discharge (Water), \*Runoff, \*Streamflow

Identifiers: \*Areal pattern of streamflow, High flow, \*Seasonal flow, \*Average annual runoff, Annual hydrograph, Daily hydrograph.

Runoff is the part of precipitation that appears in unregulated surface streams. The areal distribution of average annual runoff for 1928-63 is shown on a 1:500,000 scale map by isolines. Runoff cannot be defined in 2 areas in the Cascades because hydrologic and topographic boundaries do not correspond. The runoff pattern follows closely the pattern of precipitation and generally increases with altitude. Runoff is from 10 to 20 in. on the valley floor and increases to 90 in. in the Coast Range and 120 in. in the Cascade Range. Annual hydrographs for stations on 5 streams include 2 for streams in the Cascades, 2 for the Coast Range, and 1 for the valley floor. A daily hydrograph for the Clackamas River, 1943-45 water yr, shows the seasonal pattern of stream flow, which is similar for wet and dry yr. Runoff is high during late fall and winter as a result of heavy rainfall and snowmelt and during spring when streams draining the Cascades carry large amounts of snowmelt. Minimum flows occur during late summer and early fall when precipitation is light and temperature, high. W68-00001

# WATER SUPPLY AUGMENTATION AND CONSERVATION—Field 03

# Water Yield Improvement—Group 3B

A COMPILATION OF GROUND WATER QUALITY DATA IN ALABAMA, US Geological Survey, Water Resources Division.

James R. Ävrett.

Geol Surv of Ala Circ 37, 336 p, 1968. 2 fig, 6 tab.

Descriptors: Alabama, \*Groundwater, \*Data collections, Water wells, \*Water quality, Water sources, Irrigation water, \*Chemical analysis, Geochemistry, Hardness (Water), Water proper-

ties, Physical properties, Aquifers. Identifiers: \*Chemical analyses (Water), Water suitability, Water characteristics, Mineral con-

All available data on the quality of ground water in Alabama, up to the date of this report, are tabulated to provide information for appraising water supplies in the State and to determine whether water use is impaired. Water-quality information was obtained by various agencies and individuals in Alabama for many years, but much of the information was not published previously. The chemical and physical character of water, the significance of these properties, and the source of various constituents are discussed. Water quality requirements for domestic, industrial, irrigation, and recreational uses also are described in detail. A total of 3,692 chemical analyses are tabulated in the report, by counties. Radioelement data for 14 sites in the State are compiled in a separate table.

# WATER-LEVEL DATA FROM OBSERVATION WELLS IN THE NORTHWESTERN GULF COASTAL PLAIN OF TEXAS,

Texas Water Development Board, Austin. James W. Howard.

Tex Water Develop Board Rep 70, 209 p, Jan 1968. 9 map, 9 tab, 7 ref.

Descriptors: Texas, \*Water levels, \*Water level fluctuations, Water wells, \*Groundwater, Aquifers, \*Hydrographs, \*Observation wells, Water table, Subsurface waters, Gulf Coastal Plain, Hydrogeology, Data collections, Fluctuation, Hydrologic data. Identifiers: \*Water level changes, \*Groundwater hydrographs, Water level trends, Well data, Waterlevel measurements.

Observation wells are measured to observe changes in water levels in the principal aquifers of a 10,000 sq-mi area comprising 9 counties in southern Texas. Data are presented in the form of electronic computer printouts of well numbers, depth, altitude, date measured, depth to water, and change in water level from the previous measurement. Data are included for about 540 wells. For some wells, records go back to about 1930; for many others, records start in the 1950's. Hydrographs for representative wells in each county illustrate waterlevel changes. W68-00003

## HUDSON RIVER AS A WATER SOURCE FOR NEW YORK CITY,

Malcolm Pirnie Engineers, White Plains, NY. Robert D. Mitchell.

ASCE Proc, J Sanit Eng Div, Vol 94, No SA3, Pap 5967, pp 447-453, Jun 1968. 1 fig, 1 tab, 1 ref, 1 append.

Descriptors: \*Water supply, Hudson River, \*New York, \*River basin, Development, Drainage, Estuarine environment, Saline water intrusion, Pollutants, Water works, Cost comparisons, Aqueducts, Color, Reservoir sites, Water yield, Long-term planning, \*Storage capacity, Water quality. quality

Identifiers: \*Upland supply, Streamflow augmenta-tion, Quality standards, \*Lower river supply, Salt water problem, Yield-storage relationships.

Background characteristics of the Hudson River are described, and problems are considered regarding further development of the river system for a major augmentation of public water supply for New York City Metropolitan area. The key to develop-

ment is storage in addition to that now available. An additional upland supply of 1000 mgd is the estimated supply need of New York City and contiguous area in another 50 yr. This indicates the meed for 1300 sq mi of additional undeveloped watershed and 360 bg of storage. The Hudson River basin can furnish this amount from a wholly upland system, or water may be released from upland reservoirs and pumped from the lower part of the river at or above Hyde Park. This latter method is the least costly. W68-00007

#### ESTIMATING MEAN RUNOFF IN UNGAGED SEMIARID AREAS,

US Geological Survey, Carson City, Nev. Donald O. Moore. Bull of Int Ass of Sci Hydrol, Vol 13, No 1, pp 29-39, Feb 1968. 11 p, 7 fig, 4 tab, 2 ref.

Descriptors: \*Semiarid climates, Runoff, \*Water yield, Watersheds (Basins), \*Altitude, \*Precipitation (Atmospheric), Channel morphology, Topography, Geology, Streamflow, Vegetation, Ephemeral streams, Perennial streams, Nevada

Hydrologic data. Identifiers: \*Ungaged basins, Mean runoff, \*Runoff-altitude relations, Homogeneous regions, Precipitation-altitude relations.

Limited streamflow data are used to establish runoff-altitude relations for homogeneous regions. Where streamflow data are limited, precipitationaltitude relationships can be used to support development of the regional runoff-altitude relations. Mean runoff from ungaged basins in a homogeneous region can then be computed on the basis of this derived relation. When these relations of runoff to altitude are applied to small areas, runoff values may be different from those indicated. This is due to local differences in geology, precipitation, vegetation, land slopes, and land use. Methods are described for adjusting the relations for effects of these variations: One based on a streamflow measurement at miscellaneous sites is applicable to perennial streams; the other based on measurement of 2 channel parameters is applicable to either perennial or ephemeral streams. Curves are given that show relations of rainfall to altitude and relations of mean discharge to 2 parameters of channel cross section for ephemeral and perennial streams in Nevada. W68-00018

# PERISTENCE OF SUMMER RAINY AND DROUGHT PERIODS ON A SEMIARID RANGE-LAND,

Southwest Watershed Research Center, Tucson. H. B. Osborn.

Bull of Int Ass of Sci Hydrol, Vol 13, No 1, pp 14-19, Feb 1968. 6 p, 1 fig, 3 tab, 9 ref.

Descriptors: \*Rainfall disposition, Dry seasons, \*Arid lands, Precipitation intensity, Streamflow, Arizona, Rainfall-runoff relationships, Vegetation, Evaporation, Rain gages, Droughts, Watersheds (Basins), Wet seasons.

Identifiers: \*Rainfall persistence, \*Rangeland watershed, Dry cycle, Semiarid, Rainy periods.

In southeastern Arizona, most summer rainfall occurs as short-duration, high-intensity afternoon or evening thunderstorms of limited areal extent. About 70 percent of the 11 1/2-in. annual rainfall and 95 percent of the annual runoff occurs in July, Aug, and early Sept according to an 11-yr study in the 58-sq-mi Walnut Gulch Experimental Watershed. In contrast, 5 percent of the rainfall oc-curs in the previous 3 mo and 25 percent in the remaining 6 1/2 mo. Persistence of summer rains, although variable, represents the dependable source of water. On the average, significant rainfall was recorded for some part of the watershed during 40 percent of the July-Aug period; maximum frequency was 3 out of 4 days in 1955, and the minimum was 3 out of 10 days in 1960. The wettest year, 1955, had a continuous rainy period of 47

days; the driest, 1960, had a continuous rainy period of only 5 days. The longest summer drought occurred in 1962 when no rain fell for 17 days in Aug, following a 14-day rainy period. Precipitation records were collected from a network of 60 recording rain gages evenly distributed over the watershed. Sufficient information is not yet available to determine reliable expectancies for summer rainy or drought periods. W68-00020

# WATER FOR THE GROWING NEEDS OF HARRISON COUNTY, MISSISSIPPI,

U S Geological Survey

Roy Newcome, Jr., D. E. Shattles, and C. P. Humphreys, Jr.

U S Gool Surv Water-Supply Pap 1856, 106 p, 1968. 29 fig, 3 plate, 19 tab, 30 ref.

Descriptors: \*Water supply, \*Appraisals, Streamflow, Floods, Water quality, Groundwater, Reservoirs, Sediment discharge, Temperature, Testing, Saline water intrusion, Aquifers, Water levels, Hydrographs, Hydrologic properties, \*Flow rates, \*Mississippi, Withdrawal, Artesian wells.

Identifiers: \*Potential water sources, \*Water water flow, duration.

needs, Hydrologic environment, Flow duration, \*Harrison County, Pumping effects.

Water resources evaluations of Harrison County, Mississippi in 1966-67 reveal that an almost unlimited potential exists for the development of water supplies to satisfy the growing needs of industry and population. Storage reservoirs can be built to utilize several hundred mgd of potable water now flowing into Mississippi Sound. With proper planning and management these reservoirs can create recreational opportunities and flood control benefits. Groundwater sources now provide all the potable water supplies and are capable of providing many times the present total withdrawals of 25 mgd. Fresh water occurs in sand aquifers to depths 2,500 ft. Aquifer transmissivity ranges from 50,000 to 100,000 gpd/ft where tested. Few wells produce more than 1000 gpm, but several of the aquifers can yield 2 to 3 times that amount with wells designed for larger production. Artesian water levels are above or only a few ft below land surface in most places, and additional drawdown is economically available. Newly discovered deep aquifers (1,700-2,500 ft) have water levels 100 ft above the surface and will provide 2,000 gpm flows of 100 deg F water. The county's groundwater requires little or no treatment for most uses; it is soft with total mineral content usually less than 250 ppm. W68-00026

# DEEP-WELL INJECTION OF TREATED WASTE WATER-AN EXPERIMENT IN RE-USE OF GROUND-WATER IN WESTERN LONG

US Geological Survey, Mineola and Albany, NY.
N. M. Perlmutter, F. J. Pearson, and G. D. Bennett.

NY State Geol Ass Guidebook, 40th Annu Meeting, pp 221-231, May 1968. 11 p, 3 fig, 1 tab, 7 ref.

Descriptors: Aquifers, \*Encroachment, Sea water, Descriptors: Adulters, \*Encroachinetti, Sea water, \*Saline water intrusion, Municipal water, \*Sewage treatment, \*Recharge, Recharge wells, \*Compatibility, \*Tertiary treatment, New York, Injection wells, Dissolved solids, Hydraulics, Hydrologic aspects, Geochemistry.

Identifiers: \*Treated effluent recharge, \*Ground-water harrier ridges. Screen clogging, \*Compatiwater barrier ridges, Screen clogging, \*(bility testing, Dissolved gases, Long Island.

Cretaceous to Pleistocene aquifers on Long Island contain trillions of gallons of recoverable water. Average withdrawl was 440 mgd in 1966. The fresh water is hydraulically connected with salt water in the ocean. Because of withdrawal, salt water is encroaching into the freshwater zone. Artificial recharge experiments are intended to obtain information on the hydraulic and geochemical problems of injecting treated sewage effluent into the

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# Group 3B-Water Yield Improvement

Magothy aquifer (Late Cretaceous) as a means of maintaining seaward flow to retard encroachment while continuing withdrawal inland. The water table varies from 90 ft above to 10 ft below sea level. Discharge of 150 mgd of used groundwater to the sea has lowered the water table in the more heavily populated western end of the island. Elsewhere used water is returned, and lowering is negligible. The experimental recharge site is near the landward limit of encroachment in the western end of the island. The recharge facility is a 400 gpm tertiary treatment plant and an injection plant. Observation wells monitor the results. Experiments will be made which include varying the amount of treatment and the injection rate to study causes of clogging and compatibility effects.

W68-00028

REFORESTATION WITH CONIFERS--ITS EFFECT ON STREAMFLOW IN CENTRAL NEW YORK,

US Geological Survey, Albany, NY. Gordon R. Ayer. Water Resources Bull, Vol 4, No. 2, pp 13-24, June 1968. 12 p, 3 fig, 1 tab, 13 ref.

Descriptors: \*Reforestation, New York, Revegetation, \*Land management, Land development, Land use, \*Watershed management, Conifers, \*Runoff, Land reclamation, \*Peak discharge, \*Rainfall-runoff relationships, Discharge (Water), \*Streamflow, Base flow.

Identifiers: \*Annual runoff, Flood peak reduction, Runoff reduction, Base flow recession rates, Forest

Runoff from several reforested areas in central New York was compared with that from a nonforested control area. During the early 1930's abandoned farmland was planted with small conifers which have been allowed to grow without disturbing the existing conditions by burning, brush eradication, or denudation. The results have been a gradual reduction in winter peak runoff and total annual runoff as the trees grew. Maximum changes had occurred by about 1958; effects have been reasonably stable since then. Statistical analyses show that reforestation has reduced Nov-Apr flood peaks an average of 40%, and annual runoff by 26%. There has been no effect on peak discharge during summer, on base-flow recession rates, or on annual minimum daily flows.

W68-00034

THE FLOOD PROBLEM IN GRAND FORKS-EAST GRAND FORKS,

North Dakota Geological Survey, Grand Forks. Samuel S. Harrison.

N Dak Gool Surv Misc Ser 35, 42 p, 1968. 18 tab, 16 ref.

Descriptors: \*Floodwater, \*Flood damage, Flood control, North Dakota, Climatic data, Geologic control, Frequency, Forecasting, Dikes, Levees, Historic flood, Hydrogeologic setting, Channels, Banks, Streamflow, Ice jams, \*Maximum probable flood, \*Floodplain zoning.

Identifiers: \*River gradient, Entrenched valley, Inundation, \*Flood frequency, \*Flood-loss reduction, Peak stage.

A summary is given of flood problems, terminology, hydrogeologic setting, factors affecting flooding, and flood history of Red River at Grand Forks-East Grand Forks. Suggestions are made for damage reduction. Flowing along an axis of the gently northward tilted bed of Lake Agassiz (50 mi wide), the river meanders slowly through the area with a gradient less than 1/2 ft per mi in an entrenched valley 1/2 mi wide. River banks are only 25 ft below the uplands in many places. At Grand Forks the channel is 200 ft wide with banks 25 to 30 ft high. Severe floods spread several mi wide just north of the city. Relatively little damage is done by floods less than 40 ft high, which occur an average of once in 8 yr. A 47-ft stage makes the city water plant inoperative, and at 48 ft the power plant must

be shut down. All railroad bridges are impassable at stages over 50 ft. The river can reach an estimated height of 55 ft, which will inundate most of Grand Forks and East Grand Forks. Most floods occur in late Mar and Apr and result from the rapid melting of snow and heavy spring precipitation. A map, scale 1 in. equals 1/4 mi, shows extent of 10 yr, 30 yr, and 100 yr floods. W68-00037

ANNUAL PEAK DISCHARGES FROM SMALL DRAINAGE AREAS IN MONTANA THROUGH SEPTEMBER 1967,

US Geological Survey.
M. V. Johnson.
US Geol Surv, Helena, Mont, 139 p, 1968. 1 fig.

Descriptors: Montana, \*Floods, Discharge (Water), Stage-discharge relations, \*Small watersheds, Streamflow, Surface waters, Hydrologic data, Discharge measurement, Streams, Water year, \*Peak discharge, Gaging stations, Flooding. Identifiers: Flood peak, \*Annual flood, \*Annual peak stage, Peak stages, Small drainage areas, \*Flood data, \*High flow, Crest-stage station.

Available peak stages and discharges are given for each water yr at 228 stations for the period ending in Sept 1967. Most of the data were obtained from the operation of crest-stage gaging stations by the U.S. Geological Survey in cooperation with the Montana State Highway Commission. About 200 of the stations were operated during the 1967 water yr. Purpose of the program is to provide regional information on the magnitude and frequency of floods in the state. Most of the drainage areas are less than 100 sq mi and many are less than 20 sq mi; the largest is 1,850 sq mi. In addition to gage height and discharge for each annual flood, the tabulation contains a description of each site and the date of each annual flood. W68-00040

HYDROLOGY OF THE MONCTON MAP-AREA, NEW BRUNSWICK, Canada Department of Energy, Mines and

Canada Department of Energy, Mines and Resources.
P. A. Carr.

Can Dep of Energy, Mines and Resources Inland Waters Br Sci Ser No. 1, 25 p, 1968. 8 fig, 2 tab, 18 ref, 2 append.

Descriptors: Groundwater, \*Hydrogeology, \*Aquifers, Transmissivity, Aquifer characteristics, \*Water wells, Confined water, Glacial drift, Sandstones, Groundwater movement, \*Water yield, Permcability, Water analyses, Foreign waters, Water quality, Hardness (Water), Dissolved solids, Fresh water, Artesian wells, Fractures (Geology). Identifiers: \*Groundwater supplies, \*Yield of wells, Groundwater flow system, \*Bedrock aquifers, Fracture permeability, Canada, New Brunswick.

In most of the Moncton area, a 400 sq mi area in southeastern New Brunswick, groundwater supplies are adequate only for domestic needs. Thin, sandy glacial till covers most of the area, and locally is more than 100 ft thick. The bedrock is largely siltstone, sandstone, conglomerate, and a crystalline complex. The till and most bedrock units are poor aquifers that yield less than 20 gpm to wells. Permeability in the bedrock acquifers is related to fractures. It is highest in the northeastern part of the area where sandstones in the Richibucto Formation are well fractured. A deep fresh-water flow system has developed in that area; consequently, it is the most favorable part of the area for developing groundwater. One well is reported to yield more than 1 mgd from this aquifer and others yield 50 to 150 gpm. Groundwater is of the calcium and sodium bicarbonates types and generally contains less than 400 ppm dissolved solids. Pumping tests on 5 wells give coefficients of storage ranging from .0002 to .004 and transmissivity, from 372 to 34,400 gpd/ft. Chemical analyses of water from 58 wells are tabulated. Maps show areal values of permeability, hardness, dis-

solved solids, depth of fresh-water flow, distribution of bedrock units, and water-level contours. W68-00049

GEOHYDROLOGIC DATA FROM THE PICEANCE CREEK BASIN BETWEEN THE WHITE AND COLORADO RIVERS, NORTHWESTERN COLORADO,

D. L. Coffin, F. A. Welder, and R. K. Glanzman.
Colo Water Conserv Board Ground-Water Ser,
Circ No 12, 38 p, 1968. 20 fig, 2 plate, 4 tab, 8 ref,
1 append.

Descriptors: \*Aquifer characteristics, Drawdown, Transmissivity, Flow rates, Hydrologic aspects, \*Alluvium, Artesian wells, Surface-groundwater relationships, Hydrographs, Chemical properties, Physical properties, Sediments, Colorado, Clays, Structural geology, Test procedures, Appraisals. Identifiers: \*Hydrologic boundaries, \*Well yields, Lithology, Physical measurements, Hydraulic connection, Test holes, Piceance Creek.

Test drilling in Piceance Creak basin in Rio Blanco and Garfield Counties, northwestern Colorado, indicates the alluvium is as much as 140 ft thick with as much as 100 ft saturated. Base flow of the streams is groundwater discharge. Aquifer tests show that hydrologic boundaries in alluvial deposits affect drawdown and yield of wells after relatively short pumping periods. In places where clay beds occur in the aquifer, transmissivity may be as low as 20,000 gpd per ft, whereas if the section is mainly sand and gravel, the values may be 100,000 gpd per ft. Well yields depend on lithologic characteristics at the site and location of the well with respect to hydrologic boundaries. Initial yield per well usually is 1,000 gpm. An aquifer test for a 1,000 ft artesian flowing well in the Green River Formation indicates a range in transmissivity from 1,000 to 2,000 gpd per ft. Hydrographs streamflow at 6 gaging stations for the 1964-65 water year. W68-00050

GEOLOGY AND GROUND WATER RESOURCES OF EDDY AND FOSTER COUNTIES, NORTH DAKOTA, PART 3-- GROUND WATER RESOURCES,

US Geological Survey. Henry Trapp, Jr.

Henry Trapp, Jr. N Dak Geol Surv Bull 44, 110 p, 1968. 23 fig, 6 plate, 6 tab, 52 ref.

Descriptors: North Dakota, \*Water sources, \*Aquifers, \*Glacial drift, \*Water utilization, Water quality, Geology, Dissolved solids, Iron, Water yield, Water wells, \*Transmissivity, \*Aquifer characteristics, Water level fluctuations, Groundwater, Saline water, Municipal water, Domestic water, Stock water, Storage coefficient, Till.

Identifiers: Test holes, Yield of wells, Groundwater supply, \*Aquifer thickness, Movement of water, Pumping tests, Surficial aquifers.

The area has substantial water resources in glacialdrift aquifers but only a small part of the potential has been developed. Wells will yield 50 gpm or more in at least 20% of the area; in other places, individual wells will yield more than 1,000 gpm. Glacial till supplies water to many domestic and stock wells. Water from the more productive sand and gravel aquifers has a dissolved solids content of 250 to 2,000 ppm; in other aquifers it is up to 6,000 ppm. The water generally is hard and may have dissolved solids or iron in excess of USPHS drinking water standards. Wells supply water for 3 communities and suitable sources of groundwater are available to most other communities. The wateryielding characteristics and chemical quality of groundwater are described for 20 sand and gravel aquifers and the glacial till. Maps at scale of 1/2 in. = 1 mi show the potential yield of wells by areas, the thickness of saturated glacial drift, contours on the water table in October 1964, and lines of equal transmissibility for the drift. W68-00062

# GEOLOGY AND GROUND WATER RESOURCES OF WELLS COUNTY, PART 2--GROUND WATER BASIC DATA,

US Geological Survey. Frank Buturla, Jr.

N Dak Geol Surv Bull 51, 118 p, 1968. 2 fig. 1 plate, 5 tab, 11 ref.

Descriptors: North Dakota, Water sources, \*Aquifers, \*Water quality, \*Logging (Recording), Drill holes, \*Water levels, \*Groundwater, Water wells, Geology, Water table, Data collections, Sands, \*Glacial drift, \*Hydrologic data, \*Chemical analysis, Bedrock.

Identifiers: \*Test holes, \*Well data, Well logs, Geologic units, Sand and gravel aquifers, \*Chemi-

cal analysis (Water).

This basic-data volume is part 2 of a study. Part 1 describes the geology and part 3 describes the groundwater resources for a county near the center of the State. The basic data are useful for predicting geologic and groundwater conditions at a proposed well site in the county. Tables give 1) descriptive data for about 800 wells and test holes; 2) records for 11 springs; 3) water-level measurements in 67 wells; 4) logs of about 240 wells and test holes; and 5) chemical analyses of 76 water samples. Locations of the wells, test holes, and springs are shown on a map at scale of about 1/2 in = 1 mi. Principal aquifers in the county are sand, sand and gravel, glacial drift, and bedrock units. W68-00063

# GEOLOGY AND GROUND WATER RESOURCES OF RENVILLE AND WARD COUNTIES, PART 2-GROUND WATER BASIC

US Geological Survey Wayne A. Pettyjohn.

N Dak Geol Surv Bull 50, 302 p, 1968. 2 fig, 1 plate, 6 tab.

Descriptors: Water sources, \*Aquifers, Water wells, \*Logging (Recording), Drill holes, \*Water quality, \*Water levels, Groundwater, Bedrock, \*Glacial drift, \*Hydrologic data, \*Chemical analysis, North Dakota, Data collections, Water table, Geology, Confined water. Identifiers: Test holes, \*Well data, Well logs, Geologic unit, \*Chemical analysis (Water).

This basic-data volume is part 2 of a series. Part 1 describes geology and part 3 describes the groundwater resources of the 2 counties located in northcentral North Dakota. The basic data are useful for predicting geologic and groundwater conditions at a proposed well site. Tables list (1) descriptive data for 1,373 wells and test holes, (2) water-level measurements in 81 wells, (3) logs of 242 test holes and wells, and (4) chemical analyses of 416 water samples. Aquifers in the counties are consolidated bedrock units and glacial deposits. W68-00064

# HYDROLOGIC DATA, 1966; VOLUME 2--NORTHEASTERN CALIFORNIA, APPENDIX A--CLIMATOLOGICAL DATA. California Department of Water Resources.

Calif Dep of Water Resources Bull 130-66, 63 p, Jan 1968. 1 plate, 5 tab.

Descriptors: Meteorology, California, \*Precipitation (Atmosphere), \*Evaporation, Winds, Climatic tion (Atmosphere), \*Evaporation, winds, Climate data, Water temperature, Hydrologic data, Data collections, Meteorological data, Networks. Identifiers: Monthly precipitation, Minimum tem-perature, Maximum temperature, Maximum water temperature, Minimum water temperature

This appendix is part of an annual series presenting hydrologic data for the State. Five volumes cover the State and each volume has separate appendixes for climatological data, surface water measurements, groundwater measurements, surface water quality, and groundwater quality for its area. Tables include an index of more than 600 climatalogi-

cal stations, monthly precipitation data at each station, storage precipitation data for about 50 stations in remote areas, monthly temperature data, and evaporation data for about 50 stations. Maps at about 1:760,000 scale show locations of stations and kinds of data obtained at each. W68-00065

## GROUND-WATER RESOURCES OF LOWER MERRIMACK RIVER VA SOUTH-CENTRAL NEW HAMPSHIRE, GROUND-WATER VALLEY,

US Geological Survey. James M. Weigle.

US Geol Surv Hydrol Inv Atlas HA-277, 1 p, 1968. 1 map, 3 ref.

Descriptors: Water yield, Groundwater, Geology, Hydrogeology, Bedrock, Reservoirs, Zone of saturation, Water table, \*Aquifers, \*Water sources, \*Groundwater recharge, Water levels, \*Glacial drift, \*Hydrographs, Water wells, Porosity,

drift, "Hydrographs," Herricability, Grain-size distribution, Dune sand, \*Water-level fluctuations, Groundwater discharge, \*Yield of wells.

A 1:62,500 scale map shows ground-water availability in the 396-sq-mi area by patterns that indicate relative yields of wells. Domestic supplies are available throughout the area from glacial till or bedrock. In a narrow east side area, bedrock wells may yield 40 to 100 gpm. Large supplies are available only in local areas of stream valleys from icecontact and outwash deposits. Deposit thickness generally is less than 50 ft but may be more than 100 ft locally. Hydrographs show the 1958-66 fluctuations of water levels in representative wells. Water levels commonly rise in fall and spring and decline during the growing season. Graphs show the grain-size distribution, permeability, and porosity of outwash, ice-contact, till, and dunesand deposits. Annual precipitation of about 41 in. is uniformly distributed throughout the year. About 8 in. goes into ground-water recharge each year and is discharged into local streams. W68-00068

## ACTIVITIES OF WATER RESOURCES DIVI-SION IN ARIZONA.

US Geological Survey

US Geol Surv, Tucson, Ariz, 13 p, 1 fig, 1968.

Descriptors: \*Arizona, Hydrologic data, Stream gages, Sediment discharge, Geomorphology, Water level fluctuations, Water quality, Water temperature, Areal, Analog models, Hydrogeology, Infiltration, Evapotranspiration, Vegetation effects, Methodology, Small watersheds.

Identifiers: Basic-data collection, Program activities, Areal groundwater studies, Flood runoff, Water availability.

The water resources program of the Geological Survey in Arizona is described for fiscal 1968. The available funds of \$2,142,000 are divided as follows: cooperative program, 41%; OFA program, 5%; Federal program, 54%. The basic-data program includes the operation of a network of 280 surface-water stations, measurement of water level in 800 wells and of discharge from several hundred wells, monitoring of water quality in 35 wells, and obtaining water-quality data at 12 gaging stations (8 daily), sediment data at 13 stations, and water temperatures at 21 stations. In addition, streamflow, water levels, chemical quality, and temperature are measured intermittently at many other sites. The objectives and accomplishments of 18 areal and 7 research projects in the state are described. Research projects include studies of vegetative manipulation, evapotranspiration measurement, geohydrology, infiltration, analog-model analysis, geomorphology, chronological hydrology, and flood runoff. W68-00072

GEOHYDROLOGY AND GROUND-WATER POTENTIAL OF PORTER AND LAPORTE COUNTIES, INDIANA,

US Geological Survey J. S. Rosenshein, and J. D. Hunn. Indiana Div of Water Bull 32, 22 p, 1968. 4 fig, 4 plate, 3 tab, 20 ref.

Descriptors: \*Aquifers, \*Groundwater, Indiana \*Sands, \*Safe yield, Water wells, Water quality, Groundwater recharge, \*Water yield, \*Discharge (Water), Glacial drift, Hydrologic properties, Specific capacity, Evapotranspiration, Transmissivity, Seepage, Water utilization, Hydrogeology, Bicarbonates, Confined water.

Identifiers: \*Pumpage, Groundwater discharge, \*Yields of wells, Sand aquifers, Hydrologic system, \*Groundwater availability, Potential yield

\*Groundwater availability, Potential yield.

Unconsolidated rocks form a hydrologic system with a potential yield of 900 mgd-700 mgd from unit 3 and about 70 mgd from unit 1. Units that comprise the system are: unit 1, surficial sand in a band paralleling Lake Michigan; unit 2, silt till; unit 3, sand containing gravel; unit 4, a clay till. Discontinuous zones of sand and gravel in units 2 and 4 supply water locally for domestic and farm use. Unit 3, the principal aquifer, averages about 100 ft in thickness and has a coefficient of transmissibility ranging from about 10,000 to more than 150,000 gpd/ft. Unit 3 is about 15% artesian and 85% water-table. Recharge is from local precipitation and must percolate through overlying till in many places. Natural discharge is principally by seepage to ditches and streams and by evapotranspiration. In 1960, evapotranspiration from unit 3 was about 250 mgd during the growing season. Total pumpage in the 2 counties is about 12 mgd, nearly 50% for municipal use and 40% for domestic and farm use. Tables show data for water quality, aquifer characteristics, and geologic units. Maps show areal distribution of geologic units, bicarbonate in ground water, aquifer capabilities, and depth to water-bearing zones. Small maps show the piezometric surface, saturated thickness, and yields of wells. W68-00177

# AVAILABILITY OF GROUND WATER IN THE CLATSOP PLAINS SAND-DUNE AREA, CLATSOP COUNTY, OREGON,

US Geological Survey.

F. J. Frank US Geol Surv open-file rep, 12 p, Apr 1968. 5 fit, 2

Descriptors: \*Groundwater, Columbia River, \*Hydrologic aspects, Water table, Precipitation (Atmospheric), Evapotranspiration, \*Water quality, Streamflow, Geologic formations, \*Surface-groundwater relationships, Water wells, Oregon, Natural recharge, Water supply, Aquifers, Beaches, Sands, Hydrologic properties, Discharge (Water), Chemical analysis.

Identifiers: Geologic setting, Observation wells, \*Underseepage, Water level fluctuations, Saline water intrusion, \*Sand-dune hydrology.

The Clatsop Plains sand-dunes area is capable of yielding 100 gpm or more of soft to moderatelyhard water to properly spaced and operated shallow wells. The 40-sq-mi area extends from the mouth of the Columbia River southward 15 mi and lies between foothills of Tertiary bed-rock and the ocean. The dune sands are 100 ft or more in thickness and are underlain by Tertiary shale and sandstone of low permeability. About 80% of the average annual precipitation of 78.5 in. infiltrates the dune sand and about 1/4 of this is discharged by evapotranspiration. The remainder of the infiltrate is eventually discharged to the ocean by seeps and underflow. Much of the discharge could be captured by pumping from wells operated so as to prevent the intrusion of sea water. Maps, scale 1:48,000, show the altitude of the water table for the Oct. low period and the Jan. high period, data on surficial geology, and chemical quality of the water. Figures include sections through the dune

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area of several hydrographs. Tables give data on test-well performance and chemical analyses of water from selected wells and surface sources. W68-00178

# STORAGE REQUIREMENTS TO AUGMENT LOW FLOWS OF MISSOURI STREAMS with a section on SEEPAGE LOSSES,

Missouri US Geological Survey.

James H. Williams, and John Skelton.

James H. Williams, and John Sketton. Missouri Geol Surv and Water Resources Water Resources Rep 22, 78 p, May 1968. 6 fig, 1 plate, 1

tab, 15 ref, 1 append.

Descriptors: \*Streamflow, \*Low flow, \*Low-flow augmentation, Missouri, \*Reservoir storage, Resevoir leakage, Reservoir silting, Evaporation, Mass curves, Frequency analysis, Seepage, Runoff, Stream gages, Gaging stations, Water resources development, Statistical methods, Regulation, \*Draft-storage curves, Discharge (Water), Hydraulics, Design flow.

Identifiers: \*Storage requirements, \*Frequencymass curves, \*Recurrence intervals, Reservoir losses, Frequency curves, Ungaged sites.

Storage requirements for selected draft rates at 226 gaging stations on unregulated streams, and methods of determining storage needed at ungaged sites are presented; ways to estimate reservoir losses are suggested. An appendix table lists for each station the amount of storage required to maintain 2 to 5 selected draft rates for recurrence intervals of 20 yr, or where longer records are available, for intervals of 10 and 30 yr. Storage requirements used are based on within-yr storage analyses using the frequency-mass-curve method. The procedure involves drawing low-flow frequency curves which are used to prepare frequencymass curves for specific recurrence intervals. Draft and storage data extracted from the frequencymass curves are then used to plot draft-storagefrequency curves from which data on draft rates corresponding storage requirements are selected for inclusion in the table. Principal reservoir losses are from evaporation, sedimentation, and seepage. Evaporation can be estimated from a map included in the report. A table provides data on sedimentation. The general magnitude of seepage loss for different physiographic regions is discussed. Examples show how to use data in the report to estimate storage requirements at gaging stations and at ungaged sites. W68-00179

# WATER RESOURCES AND SURFICIAL GEOLOGY OF THE MENDENHALL VALLEY, ALASKA,

William W. Barnwell, and Charles W. Boning.
U S Geol Surv Hydrol Invest Atlas HA-259, 6 p,
Jan 1968. 1 map.

Descriptors: \*Water resources, \*Water quality, \*Water sources, Silts, \*Brackish water, Saline water, Water wells, Groundwater, Surface water, Discharge measurement, Rainfall-runoff relationships, Water utilization, Chemical analysis, Saline water intrusion, Low flow, Hydrographs, Alluvium, \*Lakes, Alaska, Glaciers.

Identifiers: Glacial silt, Geologic history, Stratigraphy, Groundwater availability, Surface-water availability, Infiltration galleries.

As part of an overall cooperative investigation of the water resources of the Great Juneau Borough, fieldwork from July 1965 through May 1966 is reported under the aspects of surface and groundwater availability, water quality, geology, and geologic history. Graphic data depicts mean daily discharge for Mendenhall Lake, Auke Creek; daily and monthly precipitation was recorded at Juneau Airport. Streamflow measurements in cubic ft/sec are tabulated, and selected chemical analyses of water samples are included. Daily and monthly hydrographs are given for 3 streams. Present water use is estimated at 882,000 gpd. In general, surface

water is soft and chemical quality is good, except for objectionable amounts of glacial silt. Salt or brackish water occurs in the shallow estuarine deposits in parts of the south end of the Mendenhall Valley and is reported from deep wells in the central part of the valley. A one-page atlas includes maps at scales of 1:31,680 and 1:62,500 showing geology, quality of surface and groundwater, water-level contours, and paleogeography of the area. W68-00182

# INFLUENCE OF ENVIRONMENT ON SHOOT GROWTH AND TOTAL CARBOHYDRATE RESERVES OF SALTCEDAR,

USDA Agricultural Research Service, Las Lunas,

Eugene E. Hughes.

Weeds, Vol 15, No 1, pp 46-49, Jan 1967. 4 p, 4 fig.

Descriptors: \*Tamarisk, New Mexico, Atmospheric pressure, Soil temperatures, Air temperature, Humidity, Winds, Solar radiation, Water qualtiy Evaporation, Carbohydrates, Root systems, Plant growth, Plant physiology, Weed control, Herbicides, Environmental effects, Cutting management, Correlation analysis, Vegetation regrowth.

A three-year study (1962-1964) on saltcedar (Tamarix pentandra Pall.) was conducted on the Rio Grange floodplain near Bernardo, New Mexico, to relate carbohydrate levels to plant shoot growth and environmental conditions, thereby estimating the most susceptible stage of growth for application of herbicides. Environmental variables included air and soil temperatures, humidity, wind, barometric pressure, solar radiation, depth to water table, water quality and evaporation from a free water surface. Total shoot length was the best estimate of carbohydrate level in storage organs of saltcedar. With the variables used, none were reliable in indicating the level of minimum carbohydrate storage or maximum shoot growth. Weekly growth patterns revealed considerable variation in growth rate and total carbohydrate storage in roots and stems. These were probably a reflection of a variation in growth. W68-00258

# WATER-SALT REGIME OF FLOODPLAIN SOILS OF CISCAUCASIA BASED ON THE KUMA RIVER VALLEY,

Ciscaucasian Scientific Research Institute for the Study of the North (PNIIIS).
S. P. Sokolovskiy.

Soviet Soil Sci, No 7, pp 962-972, July 1967. 11 p, 4 fig, 3 tab.

Descriptors: Drainage patterns (Geologic), River basins, Leaching, Soil profiles, Capillary action, Irrigated land, Moisture content, Soil moisture, Arid climates, Saline soils, Permeability, Evaporation, Water balance, Groundwater, Water loss, \*Regime, \*Floodplains, Salts, \*Grasslands, Seepage, Chlorides.

Identifiers: Kuma River Valley, USSR, Water-salt regime, Aridity, Solonchak.

The factors determining the water-salt regime of floodplain soils in the steppe part of Ciscaucasia are aridity, extensive development of salt-bearing materials in river basins, low water and brief periods of flooding, increased mineralization of river and groundwaters, predominance of fine-textured clay soils, poor natural drainage and a very low water permeability of soils and underlying materials. The water regime was divided into the seepage, with meadow and solonchak subtypes, leaching and nonleaching. A seasonable-reversible type of salt regime was established in the meadow water regime and no upward rise of salts was observed in wet years even during the summer. The absolute amounts of water soluble salts in the upper 0.5 m layer usually did not exceed the concentrations permissible for plants (0.25-0.3%). The chloride content varied between 0.06 and 0.020%.

In the dry climate regions of Ciscaucasia, a downward capillary flow had brought about an accumulation of large amounts of water soluble salts (3+%). Leaching water regime was formed in areas which had a sufficiently natural or artificial drainage. A nonleaching water regime was observed in the non-irrigated regions of floodplains which had been groundwaters. The salt regime was of the seasonal-reversible type. W68-00272

# RESERVOIR OPERATION FOR IRRIGATION AND FLOOD CONTROL IN ARID AREAS,

Sir M. MacDonald and Partners, Lion House, Holborn, London.
J. H. Fleming.

Int Comm on Irrig and Drainage, Sixth Congress, Vol 5, Question 22: 22.117-22.135, 1966. 19 p, 1 fig, 3 tab.

Descriptors: \*Reservoir operation, \*Irrigation programs, Discharge (Water), \*Flood control, \*Arid lands, Sediment transport, River flow, Evaporation, Water utilization, Distribution patterns, Field crops, Reservoir yield, Water loss, Silting, Water storage, Bypasses, Dams, Runoff, Monsoons. Identifiers: West Pakistan.

Reservoir projects in arid zones present special dif-ficulties because of the extreme variability of annual and seasonal river discharges, excessive evaporation from the reservoir surface, heavy transport of sediment and the possibility of floods whose magnitude is very large in relation to the average annual discharge. Reservoir operation stu-dies for two ephemeral 'flashy' rivers in the arid Kachhi area of Pakistan were investigated. Since flood water provided the irrigation supply there was no hard and fast line between storage available for irrigation and storage for flood control because the normal operation of the reservoirs served both purposes simultaneously. The Talli Project reservoir operation followed the proposed cropping pattern. The problem was to determine the cropping pattern which would give the biggest overall farming production with the water supplies available. The irrigation releases from the reservoir for each month of the full cropping system are given. The average annual evaporation losses, frequency of cropping and sediment accumulation in the various reservoirs were determined for a 50-year operation. On the Nari river, a system was devised by which 64% of the flood discharge could by-pass the reservoir if required, thus reducing the quantity of silt deposited there. W68-00274

#### SAND AND COTTON BUR MULCHES, BERMU-DAGRASS SOD, AND BARE SOIL EFFECTS ON: I. EVAPORATION SUPPRESSION, USDA Soil and Water Conservation Research Divi-

sion, Weslaco, Texas.
C. L. Wiegand, M. D. Heilman, and W. A.

C. L. Wiegand, M. D. Heilman, and W. A.
Swanson.

Soil Sci Soc Amer Proc, Vol 32, No 2, pp 276-280. 5 p, 4 fig, 2 tab, 19 ref.

Descriptors: \*Evaporation control, Rio Grande, Texas, \*Salinity, Soil moisture, Land reclamation, Temperature, Water storage, Bermudagrass, Water conservation, Leaching, Water table, Rainfall, Cotton, Mulching. Soil temperature, Sands, Saline soils, Water loss. Identifiers: \*Soil cover.

The effect of mulches on salinity reclamation was studied in an area east of Raymondville, Texas. The soil was a clay loam saline phase and soil cover treatments utilized were 1.5 cm thick mortar sand mulch; 44,800 kg/ha cotton bur mulch (Gossypium hirsutum); coastal bermudagrass sod (Cynodon dactylon L) and bare fallow. Measurements of moisture, water table, and temperature changes were recorded over a period of three years. Rainfall, an all important factor in leaching totalled 101, 86 and 73% of normal (27 inches) in years 1963, 1964 and 1965 respectively. Sand and cotton bur

# WATER SUPPLY AUGMENTATION AND CONSERVATION—Field 03

# Conservation in domestic and municipal Use—Group 3D

mulches effectively retained soil moisture even at shallow depths of the 0-61 cm soil depth measured. Comparison of surface water with the bare fallow showed 1.38 cm more under sand, 1.32 cm more under burs and 2.85 cm less under grass sod. Measurements of maximum and minimum soil temperatures were in the order sand mulch>bare soil>cotton burs>bermudagrass. Suction of soil moisture was low under the mulches and even moderate amounts of rainfall rewet the soil to field capacity. W68-00276

DETERMINING WATER SOLUBLE SALT RESERVES IN SALINIZED SOILS,

Biological Institute, Siberian Branch, USSR Academy of Sciences. S. N. Selyakov.

Soviet Soil Sci, No 7, pp 957-962, July 1967. 6 p, 4

Descriptors: \*Saline soils, \*Dissolved solids, \*Soil formation, Cation exchange, \*Electrolysis, Salts, Arid lands, Separation techniques. Identifiers: \*Elutriation.

Arid areas are characterized by extensive distribution of salinized soils. The productivity of the area is largely determined by the amount and composition of water soluble salts. Four methods were examined to determine all water salt reserves in salinized soils. The method of water extracts does not dissolve the bulk of salts in strongly salinized soils. By the use of electrolysis, it is possible to create conditions for the total displacement of water soluble salts from soils. The direct displacement of soil solutions was the third method and involved many drawbacks. The use of decanted water extracts was the best method to determine soluble salt reserves in salinized soils. W68-00285

# A WIND-OPERATED AUTOMATIC POWDER DISPENSER FOR EVAPORATION SUPPRES-

Canada Department of Agriculture, Research Station, Swift Current, Saskatchewan.

W. Nicholaichuk, and K. Pohjakas.

Canadian J Soil Sci, Vol 47, No 1, pp 79-80, Feb 1967. 2 p, 1 fig.

Descriptors: Evaporation, \*Evaporation control, \*Alcohols, Wind velocity, \*Monomolecular films,

An automatic device for dispensing fatty-alcohol powder for evaporation control in ponds and lakes has been developed. The unit consists of a wind driven fan that supplies power to drive the dispenser, an adjustable governor-controlled clutch, a speed reducer, and a dispensing unit. The dispenser operated at wind speeds between 3 and 10 miles per hour. The transmission of power to the dispenser was interrupted at wind speeds above 10 miles per hour since this was the range when the wind prevents the formation of a monomolecular film cover. W68-00287

# PONTACYL BRILLIANT PINK AS A TRACER CYE IN THE MOVEMENT OF WATER IN PHREATOPHYTES.

U. S. Geological Survey, Menlo Park, Calif. T. W. Robinson, and Donald Donaldson. Water Resources Res, Vol 3, No 1, pp 203-211, 1967. 9 p, 5 fig.

Descriptors: Soil water movement, Plant physiology, Soil-water-plant relationships, \*Water utilization, Evapotranspiration, Soil moisture, Tracking techniques, Test procedures, Tracers, Dye releases, Leaves, Fluorescence, \*Phreatophytes, Lysimeters, Fluorometry, Transpiration, Osmosis, Sampling.

Pontacyl Brilliant Pink, a fluorescent dye, was used to trace the movement of water in two species of woody phreatophytes, willow and wildrose, in connection with evapotranspiration studies near Winnemucca, Nevada. Pontacyl Brilliant Pink was selected from a number of dyes on the basis of previous investigations. The cost was equivalent to 3 1/2 cents per gram and 25 grams of the dye were introduced into the water distribution systems of the plants. Leaf samples, collected periodically, roots, stems and transpired water collected in plastic bags were analyzed and found to contain the dye. The analytical procedure is fully described including variables in the method which included solvents, time of heating an,d pH of the filtrate. The fluorometric determinations were made with a G K Turner Fluorometer model 111 using a standard curve. Dye concentration was greatest in the upper part of the stems. W68-00300

# RETENTION OF WATER BY PLANT CELL WALLS AND IMPLICATIONS FOR DROUGHT RESISTANCE,

University of Western Australia, Perth. T. S. Teoh, L. A. G. Aylmore, and J. P. Quirk. Aust J Biol Sci, Vol 20, No 1, pp 41-50, Feb 1967. 10 p, 2 fig, 32 ref.

Descriptors: Root systems, Plant tissues, \*Cytological studies, Plant physiology, \*Drought resistance, Moisture stress, Sorption, \*Xerophytes, Moisture content, Water requirements, \*Adsorption, Xylem, Isotherms, Moisture deficit, Monocots, Desert plants, Transpiration, Dicots.

The sorption-desorption isotherms for root cell walls of two monocotyledons (Ehrharta calcycina Sm. and Triticum vulgare Vill. cv. Gabo) and two dicotyledons (Salicornia australis Banks and Soland and Vicia faba L) were studied in Australia. Wall materials from Young roots were prepared using a standard method so data could be directly compared. When water content was compared against water potential the water intake increased exponentially as water stress decreased. It was suggested that during periods of drought xerophytes must possess a greater resistance to the destruction of the two phase nature of the cell wall (solidliquid) system than do mesophytes. Other factors of drought resistance such as root system and specialized adaptations were also discussed.

# 3C. Use of Water of Impaired **Ouality**

# **GROUND-WATER GEOLOGY OF KORDOFAN** PROVIDENCE, SUDAN, US Geological Survey. Harry G. Rodis, Abdulla Hassan, and Lutfi

Wahadan.

US Geol Surv Water-Supply Pap 1757-J, pp J1-J48, 1968. 48 p, 9 fig, 1 plate, 6 tab, 30 ref.

Descriptors: \*Foreign countries, \*Groundwater, \*Aquifers, Withdrawal boreholes, \*Deserts, Zone of saturation, Confined water, \*Groundwater \*Foreign countries, \*Groundwater, basins, Groundwater recharge, Groundwater movement, \*Water wells, Water quality, Water analysis, Sandstones, Geology, \*Hydrogeology, Dissolved solids, Water levels, Potentiometric level, Rainfall, Water sources.

Identifiers: \*Groundwater potential, Africa, Sudan, Artesian zone, Dug wells, \*Perennial supplies, Well data, Surficial deposits.

Kordofan providence, in the White Nile-Nile River basin of central Sudan, is a plain of low relief with annual rainfall ranging from less than 100 mm in north to about 800 mm in south. Perennial groundwater supplies occur in sandstone or conglomerate aquifers in the Nubian Series or Umm Ruwaba Series or both. Depth to the top of the saturated zone ranges from about 50 to 160 meters. Surficial deposits of sand and clay mantle the entire area, but generally serve as only temporary sources of water. Basement rocks also are poor aquifers. Some 175 drilled wells at 75 water yd yield an average of about 1,000 imperial gph. The best quality water in the Nubian aquifers has dissolved solids ranging from 100 to 340 ppm and hardness from 60 to 264 ppm. Water in the Umm Ruwaba aquifers ranges from 420 to 3,000 ppm dissolved solids and averages 1,050 ppm. Use at the 1962 rate of about 600 million gal probably could be continued almost indefinitely. Aquifers in the southwestern part of the providence have potential for additional development. Nubian aquifers in the northern part need test drilling to evaluate. Tables give data for 250 drilled and 100 dug wells, well logs, and analyses of 18 water samples. W68-00017

# OCCURRENCE OF SOIL SALINITY IN THE DRY LANDS OF SOUTHWESTERN ALBERTA, Canada Department of Agriculture, Soil Research Institute, Ottawa.

G. M. Greenlee, S. Pawluk, and W. E. Bowser. Canadian J Soil Sci, Vol 48, No 1, pp 65-75, Feb 1968. 11 p, 5 fig, 3 tab.

Descriptors: \*Saline soils, Dissolved solids, Arid lands, Sodium, Piezometers, Geomorphology, Soil chemical properties, Groundwater movement, Surface-groundwater relationships, Water table, Magnesium compounds, Aerial photography, \*Ground-water, Soil profiles, Bedrock, Seepage, Wells, Gla-cial soils, Till, Soil analysis, Salt balance, Salts. Identifiers: Alberta, Canada, \*Resalinization.

The soil parent material of southwestern Alberta, Can, has a high salt content. Sunshine, rainfall (27 in) and wind create conditions that produce high salt concentrations in the soil. The objectives of this project were to study groundwater movement and salt distribution to determine the source and movement of the salts and how this influences the resalinization upon genetic soil characteristics. Soil profiles were examined, shallow wells and piezometers were installed to measure groundwater flow and salt movement. Soil and parent geologic material samples were collected for analysis. A high sodium content in the soluble-salt composition of groundwater, saline soils and parent geologicmaterial suggests bedrock to be the main source of the salts. Glacial till participates to a lesser extent. By the use of a dye indicator, it appeared that both regional and local groundwater discharges were responsible for the salt movement. Agronomic practices and rainfall occurrence and intensities play a role in regulating groundwater flow. W68-00291

# 3D. Conservation in domestic and municipal Use

# A DECADE OF EXPERIENCE UNDER THE IOWA WATER PERMIT SYSTEM-PART ONE, New Mexico Univ. School of Law, Albuquerque. N William Hines.

Natural Resources J, Vol 7, No 4, pp 499-554, Oct. 1967. 56 p, 5 tab, 183 ref.

Descriptors: Administration, \*lowa, \*Beneficial Descriptors: Administration, \*Iowa, \*Beneficial use, Water pollution, \*Administrative agencies, \*Water law, \*Water policy, \*Water control, Administrative decisions, Legal aspects, \*Legislation, Permits, \*Water permits, Water rights, Inter-agency cooperation, \*Political aspects, Preferences (Water rights), Riparian rights, Regulation, Planning, Flow.

Identifiers: \*Permit system, \*Summation flow doc-

lowa water law is an uncertain combination of legislation layered on common law; but its redeeming feature is an administrative agency operating, enforcing, and bringing order to the statutory permit scheme. The permit statute distinguished regulated and non-regulated uses, requires a beneficial use for granting a permit, and protects streams by the concept of an established average minimum flow. The scheme regulates the taking of water from any surface or underground source for any

# Field 03—WATER SUPPLY AUGMENTATION AND CONSERVATION

# Group 3D—Conservation in domestic and municipal Use

purpose other than an unregulated use. The principal nonregulated uses, roughly are: household; municipal and industrial uses at the effective date of the statute; and uses of less than 5000 gallons daily. Pollution and the permit system are controlled by separate but closely cooperating agencies. Procedure for application and approval of a permit is discussed in detail. The hybrid nature of the lowa system is analyzed. The uniform regulation of water without regard to the form it takes and the concept of a water right limited in duration are singular features of the scheme. Problems of interpretation and application in administering the system are detailed. No priority of uses is officially recognized. W68-00106

A DECADE OF EXPERIENCE UNDER THE IOWA PERMIT SYSTEM-PART TWO,

New Mexico Univ. School of Law, Albuquerque N. William Hines.

Natural Resources J, Vol 8, No 1, pp 23-71, Jan 1968. 59 p, 9 tab, 115 ref.

Descriptors: Administration, \*lowa, \*Beneficial use, \*Administrative agencies, \*Water law, \*Water policy, \*Water control, Water management (Applied), Flow control, \*Administrative decisions, Legal aspects, \*Legislation, \*Political aspects, Preferences (Water rights), Riparian rights, \*Water permits, Water rights.

Identifiers: \*Permit system, \*Summation flow doc-

Procedure for processing original application is examined both as to statutory requirements and practical functioning. This includes a discussion of pretrial investigation, hearings, and procedure for appeal. Transfer of permits, subject to the qualification that the permit attaches to the land rather than the person, is permitted. Procedure for renewal and modification of permits is discussed. Permits may be terminated or suspended without the consent of the permittee upon enumerated statutory grounds, and may be summarily suspended in emergency situations. Although the constitutionality of the Iowa system has never been challenged, three constitutional principles may possibly be invoked to challenge its validity: substantive due process, procedural due process, and delegation of powers. Each of these lines of attack is examined; and although problems arise in other areas, the stiffest challenge may lie in the area of improper delegation of legislative powers. The article concludes that due to lack of extended drought, the Iowa permit system has yet to face serious challenge. Also, aside from irrigation, water users have approximately-the same right under the statute that they had under common law. The principal recommendation is that research be initiated into a priority system. W68-00112

EMERGING PATTERNS FOR REGULATION OF CONSUMPTIVE USE OF WATER IN THE EASTERN UNITED STATES,

Indiana Univ. School of Law, Bloomington. Sheldon Plager, and Frank E. Maloney Ind L J, Vol 43, No 2, pp 383-405, Winter 1968. 23

Descriptors: \*Consumptive use, Withdrawal, \*Water consumption (Excludes consumptive use), \*Regulation, Beneficial use, \*Southeast U. S., \*Water law, \*Northeast U. S., Water policy, Administrative agencies, Judicial decisions, Legisla-tion, Preferences (Water rights), Riparian rights, Water rights, \*Water permits, Prior appropriation, Riparian land.

Identifiers: Constitutionality, \*Water permit system, Regulatory goals, \*Eastern U. S.

The article first examines the weaknesses of the common law approach to allocation of water for consumptive use. The major criticism of the riparian system involves its uncertainty. Concern over the adequacy of existing laws to cope with waterresource problems has led to new proposals and the legislative creation in a number of eastern states of administrative authorities with varying powers to grant permits authorizing the withdrawal of water from streams. This activity has in turn raised a number of problems, one being the constitutionality of regulating the consumptive use of water. A detailed study of the regulation of withdrawals under eastern permit systems, along with the goals of these systems, is presented. Permit systems are classified as compulsory and permissive, the compulsory systems being divided into general compulsory systems and compulsory permits for special problem areas. The laws and practices in the states within these categories, the problem of the use of water beyond riparian land, and the advantages and disadvantages of the eastern permit systems are examined. Western consumptive use regulations are analyzed, and a summary and conclusion is set W68-00164

## 3F. Conservation in Agriculture

#### RIPARIAN RIGHTS IN THE SOUTHEASTERN UNITED STATES,

South Carolina Bar Association.
William H. Agnor.
S C L Q, Vol 5, No 2A, pp 141-148, Dec 1952. 8 p, 33 ref.

\*Relative rights, \*Southeast U. S., \*Natural flow doctrine, tion water, Prior appropriation, Reasonable use, Riparian land, Riparian rights, Water law, Water utilization, Alteration of flow, Non-navigable

The relative rights of riparian owners on nonnavigable watercourses to use water for irrigation purposes are discussed. Irrigation is a consumptive use and both detains and diminishes the flow of a stream. Each riparian proprietor is entitled to have the watercourse flow by or through his land in its natural course, quality, and quantity, subject to reasonable use by others. In the southeastern states the general rule is 'reasonable use of water for domestic, agricultural and manufacturing purposes.' The riparian owner probably cannot use his riparian water to irrigate or nonriparian land. Use of water on the riparian land must be reasonable. The doctrine of prior appropriation is examined as a possible method of clarifying the right to use water for irrigation. It is unlikely that the prior appropriation doctrine could be adopted in the southeastern states because of constitutional objec-W68-00242

# IRRIGATION WITH NON-RIPARIAN SURFACE WATER AND SUBTERRANEAN WATER IN KENTUCKY,

Kentucky Univ., Lexington. George B. Baker. Ky L J, Vol 42, No 3, pp 493-497, Spring 1954. 5 p 27 ref.

Descriptors: \*Kentucky, \*Irrigation, \*Percolating waters, \*Diffused surface waters, Water law, Drainage, Water utilization, Irrigation water, Irrigation practices, Water policy, Subsurface

Irrigation water in Kentucky is derived from riparian surface streams, impounded non-riparian surface water, and subterranean water. This article examines the law governing the use of irrigation water derived from: (1) underground streams (2) percolating waters (3) diffuse surface water. Kentucky applies the ordinary riparian rules of reasonable use and natural flow to underground streams. Right to use percolating waters is based on the theory that ownership of land includes ownership of percolating water on the land. The use made of percolating water may not be malicious or unnecessary, nor may one owner so pollute percolating water that it is unfit for his neighbor's use. There is no

general common-law rule in Kentucky as to a landowner's right to the use of diffused surface water on his property. However, a lower owner may not obstruct natural drainage, and the upper owner may not collect and release large volumes of diffused surface water on the lower owner or divert drainage to cast an unnaturally large flow upon the lower owner. The article concludes that an owner may use all of his percolating and non-riparian surface water for irrigation. W68-00243

# WATER USE OF DRY-FARMED ALMONDS UNDER CLEAN AND NONCULTIVATION CON-DITIONS.

University of California, Davis.

David Holmberg. Calif Agr, Vol 21, No 9, pp 6-7, Sept 1967. 2 p, 3

Descriptors: Dry farming, Cultivation, \*Cover crops, Transpiration, \*Moisture uptake, Deciduous trees, Field capacity, Wilting point, Soil moisture, Moisture stress, Sampling, Farm management, Soilwater-plant relationships, \*Orchards, Soil tests,

Absorption. Identifiers: Yolo County, Calif., \*Almonds.

A 3-year study was conducted on a dry-farmed almond orchard in the Capay Valley of Yolo County to determine whether there is additional water use by a cover crop under noncultivated as compared to cultivated conditions. Samples for soil moisture determination were taken to depths of 6 feet. Results indicated that there was a slightly greater water extraction from the noncultivated plots in years of lush cover crop growth. Most deciduous fruit trees withdraw water from field capacity to the wilting point at the same rates, whereas almonds apparently respond to increasing soil-moisture stress by reducing the rate of extraction. W68-00275

## THE TRANSPIROMETER FOR MEASURING THE TRANSPIRATION OF DESERT PLANTS,

Desert Research Institute, University of Nevada, Reno, Nevada.

J of Hydrol (Amsterdam), Vol 5, No 2, pp 143-157, 1967. 15 p, 11 fig.

Descriptors: \*Transpiration, \*Desert plants, Plant pigments, Plant physiology, Electrical equipment, Moisture content, Model studies, On-site tests, Meausrement, \*Water loss, Temperature, Flowering, Leaves, \*Stomata, Hygrometry, Model studies, Humidity.

Identifiers: \*Transpirometer, Desert Res Inst, Univ of Nevada, Reno.

The electronic hygrometer was used in studies of plant transpiration near Winnemucca, Nevada. Measurements of water lost were performed on sagebrush (Artemisia tridentata), shadscale (Atriplex canescens), rabbitbrush (Chrysothamnus), saltgrass (Distichlis stricta), and greasewood (Sarcobatus vermiculatus) using the hygrometer and a crude quick triple beam balance for comparison. The results of both methods showed close correlation. correlation. Results showed dark green leaves of greasewood controlled water loss more efficiently than yellow green leaves of the species and water loss from greasewood differed in condition from saltgrass clumps. The hygrometer alone was used to record transpiration from five branches of a rabbitbrush and five of a sagebrush plant from flowering through fruit dispersal during two fall months. Both plants controlled water loss during fruit expansion with little effect from air temperature and relative humidity. W68-00277

DIFFUSION RESISTANCE, ILLU-MINANCE, AND TRANSPIRATION,

U. S. Department of Agriculture, Soil and Water Conservation Research Division, Phoenix, Ariz. W. L. Ehrler, and C. H. M. van Bavel.

Control of Water on the Surface—Group 4A

Plant Physiol, Vol 43, No 2, pp 208-214, Feb 1968. 7 p, 2 fig, 2 tab.

Descriptors: \*Transpiration, Photosynthesis, Environmental effects, Light intensity, Boundary layers, Transpiration control, Evaporation, Evapotranspiration control, Water loss, Vapor pressure, Hydrostatic pressure, Plant physiology, Resistance, \*Stomata, Water vapor, Leaves, Epidermis, Diffusion, Field crops, Density.

Identifiers: Contolled environment, \*Illuminance,

The effect of illuminance on leaf diffusion resistance was studied on the following 8 plant species: alfalfa, snap bean, fava bean, cotton, sunflower, lemon, corn and sorghum at the U.S. Water Conservation Laboratory, Phoenix, Ariz. Progressive stomatal opening was induced by stepwise increases in fluorescent illuminance. This was evidenced by decreases in leaf diffusion resistance ranging from 15 to 70 sec cm-1 in darkness to about 1 sec cm-1 at about 40 kilolux. By extrapolating their data the authors found that full stomatal opening would occur at 50 kilolux. Transpiration calculated from a determination of (1) the difference in water vapor density from leaf to air, (2) the boundary layer resistance, and (3) the leaf diffusion resistance agreed reasonably with that measured by weight loss in four species. Transpiration can be expressed quantitatively in terms of a few relatively simple parameters. W68-00283

SAND AND COTTON BUR MULCHES, BERMU-DAGRASS SOD, AND BARE SOIL EFFECTS ON: II. SALT LEACHING,

USDA Soil and Water Conservation Research Division, Weslaco, Texas.

M. D. Heilman, C. L. Wiegand, and C. L. Gonzalez.

Soil Sci Soc Amer Proc, Vol 32, No 2, pp 280-283. 4 p, 4 tab, 2 fig.

Descriptors: Rio Grande, \*Evaporation control, Soil chemical properties, Inorganic compounds, Anoin adsorption, Soil amendments, Land reclamation, Stubble mulching, Electrical conductance, Leaching, Saline soils, Bermudagrass, Texas, \*Salinity, Chlorides, Sulphates, Gypsum, Mulching, Cover crops, Salts, Conductivity, Cotton, Sorghum.

Identifiers: Cations, Soil cover.

Salinity reclamation was studied with and without gypsum in an area east of Raymondville, Texas. soil covers of sand mulch, bur mulch (Gossypium hirsutum), coastal bermudagrass sod (Cynodon dactylon L.) and bare fallow were employed. Electrical conductivity was decreased in saturated soil extracts of all treatments. Before treatment all profiles were NaCl dominated. All cations decreased in the 0-61 cm profile. Sodium and calcium were the dominant cations in the system both before and after treatment. The ratio of Na+ to Ca++ removal was 1.6, 1.3, 1.4 and 1.2 for bermudagrass, sand, cotton bur and bare fallow treatments for nongypsum treatments. The ratios with gypsum were 0.9, 1.2, 1.5 and 1.1 for bermudagrass, sand, cotton bur and bare fallow treatments respectively. The decrease in electrical conductivity was from 1.76 mmhos/cm to 2.8 mmhos/cm for the most effective sand mulch for the first year. After a cropping season with sorghum the electrical conductivity remained unchanged. Sand and bur treatments yielded a net reduction from 0 to 213-cm/profile and a net increase foilowed bare fallow and bermudagrass treatment. W68-00290

BECOME MORE WATER WISE PART 2 --STORAGE AND TROUGHS, South Australia Department of Agriculture, Ade-

laide. D. W. Russell

J of Agr South Australia, Vol 70, No 12, pp 425-428, July 1967.

Descriptors: \*Stock water, Water requirements, Water supply, \*Wells, Watersheds (Basin), Network design, Water tanks, Water storage, \*Dams, Equipment, Reservoir construction, Water quality, Reservoir sites, Bores. Identifiers: Australia, Windmills

Large and small supplies for livestock on the range are discussed, the first supplying a large area of the land by the use of dams and wells. The second are small water supplies that meet the livestock requirements at a small area on the range. Equipment, care, management, and livestock requirements for large and small systems are described W68-00292

VEGETATION TYPES IN THE LAS BELA RE-

GION OF WEST PAKISTAN, Clark University, Worcester, Mass; Pakistan Council of Scientific and Industrial Research, Karachi. Rodman E. Snead and Mohammad Tasnif. Ecology, Vol 47, No 3, pp 494-499, 1966. 6 p, 9 fig

Descriptors: \*Terrain analysis, Soil-water-plant relationships, Soil types, Tidal marshes, Vegetation, Arid lands, \*Xerophytes, \*Aerial photography, Remote sensing, Environment, \*Plant populations, Density, Coastal plains, Shrubs, Desert plants, Dunes, Geomorphology. Identifiers: West Pakistan, \*Indicator plants.

The vegetation of the Las Bela region of West Pakistan with an annual rainfall of 5 to 9 inches consists of scattered xerophytic shrubs and trees. Indicator species were identified on six different landform regions in the area, and by identifying their morphology on aerial photographs, the different environments were determined before the field work was done. The density of the plants, shading and aerial distribution of the vegetation were the main methods used to identify the plant species. W68-00293

A MODEL FOR TRACING SALT DISTRIBUTION IN THE SOIL PROFILE AND ESTIMATING THE EFFICIENT COMBINATION OF WATER QUALITY AND QUANTITY UNDER VARYING FIELD CONDITIONS,

Israel Ministry of Agriculture, Tel-Aviv, Israel.

Soil Sci, Vol 104, No 4, pp 227-233, Oct 1967. 7 p, 2 fig, 18 ref.

Descriptors: \*Model studies, Equilibrium, \*Irrigation water, \*Soil profiles, Water quality, Linear programming, Soil moisture, Field capacity, Soilwater-plant relationships, Leaching, \*Chlorides, Soils, Salinity.

Identifiers: Mass conservation.

Methods used for equating salt concentration in soils were limited by assumptions of steady-state conditions. In the present study a model is presented, based on the law of mass conservation, for tracing the distribution of a nonabsorbed ion in the soil profile in response to varying irrigation conditions in Israel. Parameters included soil-water characteristics, initial salinity, moisture use in each soil layer and quantity and quality of water applied at each irrigation. Data from three irrigation experiments were compared to values calculated according to the model. The model was applied using linear programming techniques for evaluation of efficient combinations of quality and quantity of irrigation water according to the desired salinity distribution. W68-00303

04. WATER QUANTITY MANAGEMENT AND CONTROL

4A. Control of Water on **THE Surface** 

FLOOD PLAIN INFORMATION, CATTARAUGUS CREEK AND THATCHER BROOK, IRVING, SUNSET BAY AND GOWANDA, NEW

US Army Corps of Engineers, Buffalo District.

US Army Corps of Eng, Buffalo Dist, NY, 68 p, Feb 1968. 17 fig, 20 plate, 14 tab.

Descriptors: \*Floods, Discharge (Water), \*Stage-discharge relations, \*Streamflow, Discharge measurement, Small watersheds, Stream gages, Gaging stations, Flow measurement, New York, Lake Erie, \*Flood damage, Floodways, \*Flood protection. Identifiers: Flood peak, \*Annual flood, \*Flood data, Peak stages, Flood frequencies, Flood measurements, Gowanda, NY

A study was made of flooding and flood damage between 1834 and 1967 on Cattaraugus Creek and its tributary, Thatcher Brook, from the mouth at Lake Erie to mi 19.5. The greatest known flood on Cattaraugus Creek, March 17, 1942, would have caused \$140,000 worth of damage in 1967. The greatest known flood on Thatcher Brook, Sept 1939, would have cost \$131,000 in 1967. Average annual damage from flooding is \$26,300 on Cattaraugus Creek and \$4,450 on Thatcher Brook at May 1967 price levels and development. Records of stage and discharge are available on Cattaraugus Creek from 1939 to the present. There are no records for Thatcher Brook. Most of the serious flooding upstream was caused by heavy rains, usually in spring when snow is melting and the ground is saturated. Serious downstream floods were all caused by ice jams on a bar across the mouth of Cattaraugus Creek. Potential flood damage is being reduced by various channel improvements including removal of a dam and periodic dredging of the bar. Twenty-one plates include flood hydrographs, profiles, topographic maps, economic development, flood area maps, and a map of the drainage basin of Cattaraugus Creek. Information was extracted from the report and presented in two pamphlets covering the Gowanda area and the area near the mouth. W68-00023

RESERVOIR EFFECT ON DOWNSTREAM WATER TEMPERATURES IN THE UPPER DELAWARE RIVER BASIN,

US Geological Survey. Owen O. Williams.

US Geol Surv Prof Pap 600-B, pp B195-B199, 1968. 5 p, 5 fig, 1 tab, 1 ref.

Descriptors: Reservoirs, \*Temperature, Water management (Applied), Streamflow, Climatology, \*Monitoring, Data collections, Gaging stations, \*Hydrographs, \*Mass curves, Thermometers, Delaware River, Air temperature, Downstream, Water transfer, Cooling.

Identifiers: Cooling water, Reservoir operation, \*Stream temperature, Measurements, \*Reservoir effects, \*Traveltime, Cannonsville, Pepacton.

Comparison of water-temperature records not affected by reservoir releases with records collected on a stream that is affected, together with knowledge of local climatologic conditions, can be used to estimate the effect of significant releases on downstream temperatures, according to data from a 3-yr study in the upper Delaware River basin. Graphical analysis of the data illustrates marked effect of releases from New York City's Cannonsville and Pepacton Reservoirs on downstream water.

# Field 04—WATER QUANTITY MANAGEMENT AND CONTROL

# Group 4A—Control of Water on the Surface

Drops occurred in water temp of 26 deg F at 8.1 mi and 8 deg F at 44.3 mi below Cannonsville, and of 20 deg F at 31 mi and 5 deg F at 59 mi below Pepacton. Five waterproof thermographs were operated at key sites from May through Oct each yr from 1964-66. Maximum and minimum air temp and precipitation records from Weather Bureau stations, and appropriate hydrographs and doublemass curves were used to determine and substantiate climatologic and release effects on downstream water temp. Reservoir releases in 1966 lowered water temp more effectively than in 1964 because of larger available storage. One-half day travel-time was required for Cannonsville Reservoir releases to effect stream temp 8 mi downstream; one and one-half days were required from Pepacton dam to Hancock, 31 mi.

CAPTURE AND DIVERSION OF RUNOFF BY SUBSURFACE CHANNELS, West Virginia Univ., Morgantown, Bethany Coll., Bethany, W Va.

W. M. Duncan, G. E. Eddy, and P. R. Errington. Proc West Virginia Acad Sci 1967, Vol 39, pp 320-326, Feb 1968. 7 p, 6 fig, 6 ref.

Descriptors: \*Underground streams, Surface-groundwater relationships, \*Karst, Limestones, Groundwater, \*Subsurface runoff, West Virginia, \*Caves, \*Sinks, \*Springs, Subsurface flow, Streams, Runoff, \*Joints (Geology), Hydrogeolo-gy, Dry beds, Perennial streams. Identifiers: Sinking stream, Karst hydrology, Limestone caves.

Along the eastern slope of Back Allegheny Mountain, in Pocahontas County, West Virginia, limestone is very effective in capturing runoff. In that area streams with relatively small drainage basins, such as the middle fork of Trout Run and the second fork of Wanless Run, flow consistently. In contrast, several streams with larger drainage basins, such as the south fork of Trout Run and the third, fourth, and fifth forks of Wanless Run, rarely have any flow. It has been observed that runoff in the dry streams runs into the ground through swallow holes (sinkholes), drains off in subsurface passageways, and emerges as springs along the perennial streams. Normally all the flow of the dry streams is diverted by one or more sinkholes. Underground passages that have been traced out trend northeastward approximately parallel to the mountain front and pass beneath the ridges between ravines. Some of these caves are fed by several waterfalls approximately beneath the dry streambeds. Study of the passages and an analysis of the joint system in the limestone indicates that the passages result from enlargement of the joints. The direction of flow is controlled by the intersection of the joints with the dipping strata. W68-00039

#### SEEPAGE FROM DITCHES--SOLUTION BY FINITE DIFFERENCES,

Utah State Univ., Water Research Laboratory, Logan.

Ronald W. Jeppson.

ASCE Proc, J of Hydraul, Vol 94, No. HYI, Paper 5763, pp 250-283, Jan 1968. 25 p, 7 fig. 3 tab, 1 ap-

Descriptors: \*Hydraulics, \*Seepage, \*Canal seepage, Water loss, Flow nets, Ditches, \*Irrigation ditches, Drainage, Mathematical studies, Com-puter models, Deep percolation, Gravitational water, Infiltration, \*Leakage, Percolation, Anisotrophy.
Identifiers: \*Canal loss, Finite-difference solution.

A digital computer is used to obtain finite-dif-ference solutions to steady-state free-surface seepage problems from canals of trapezoidal, triangular, and rectangular cross sections to drained layers at finite depths. In the formulation of the problems, the coordinate x and y are considered the dependent variables; the velocity potential and

the stream function are the independent variables. The solutions are obtained by 2 independent methods. The first method combines solutions for y and x from the plane of the velocity potential and stream function with a solution of the stream function from the physical plane in a cyclic manner. The second method uses complex arithmetic to obtain the solution entirely in the plane of the velocity potential and stream function. A variation in the formula is applicable to homogeneous anisotropic soils, provided that the boundary conditions around the canal are not altered. Graphs show potential and flow lines around canals of different shapes. Tables present solutions for x and y, a comparison of x-values from finite and analytical solutions, and a summary of seepage data for representative canals of various shapes and sizes and for several distances to the drained layer. The solutions are applicable to other seepage problems. W68-00042

# MIXED TECHNIQUE FOR COMPUTING SURGES IN CHANNELS,

Tetra Tech Inc., Pasadena. J. Ian Collins, and Samuel N. Fersht. ASCE Proc, J Hydraul Div, Vol 94, No. HY2, Pap 5831, pp 349-362, Mar 1968. 14 p, 13 fig, 4 ref, 2 append.

Descriptors: Flow, Rivers, \*Surges, Waves (Water), Floods, Hydraulic jump, \*Hydraulics, Channel flow, Channels, Hydrographs, Friction, Discharge (Water), Alteration of flow, Boundaries (Surfaces), Mississippi River, \*Numerical analysis. Identifiers: \*Surge crest profiles, Hurricane Betsy, Storm tides, Boundary conditions, Adverse current.

Computation of surge propagation within a channel is developed using a numerical procedure. The technique uses finite difference for space derivatives and a fourth-order Runge-Kutta method for time integration. It is applied to simple wave propagation in a straight uniform channel, with and without friction, to verify the procedure and numerical stability. The numerical technique is then used to analyze surge propagation observed during Hurricane Betsy, Sept 1965, in the lower reaches of the Mississippi River. Good agreement with observations is obtained. The procedure is next applied assuming higher river stages. Results show that use of such a numerical integration system is extremely effective and accurate. Computing time is comparatively short. W68-00045

# SUCCESSFUL ICE DUSTING AT FAIRBANKS,

ALASKA, 1966, Massachusetts Inst. of Technology, Cambridge, US Army Corps of Engineers, Anchorage. Gordon R. Cook, and Mason D. Wade, Jr ASCE Proc, J of Hydraul, Vol 94, No. HY1, Paper 5717, pp 31-41, Jan 1968. 11 p, 16 fig.

Descriptors: Snowmelt, \*lce jams, \*lce breakup, Alaska, \*Snow cover, \*Snow management, Solar radiation, Ice, Melt water, \*Flood control, Hydraulics, Runoff, Streamflow, Melting, Fly ash. Identifiers: \*Snow dusting, \*Stimulated melting, Spring melting, River blocking, Coal dust, River flooding, Fairbanks.

The ice and snow cover of 2 rivers downstream from Fairbanks, Alaska, was dusted in Apr 1966 to increase solar heat absorption and hasten melting. An airplane was used to spread 35 tons of fly ash and coal dust over the entire lower reach of the Chena River and along the right bank of the Tanana River below the mouth of the Chena. Four days after dusting it was noted that the dusted snow was much wetter that the undusted snow and that the dusted ice was honeycombed to depths of 4 in. Dowells with 6-in. wide colored bands were set in the ice 5 days after dusting to gauge the effect. Fifteen days after dusting, snow was nearly gone from the dusted areas and the ice feld 'rotten'. Two days later the dusted portion of the ice 'went out,' opening that part of the channel 9 days before the breakup in the undusted part. No ice jam formed on the Chena River despite a near-record snowfall during the previous winter. Measurements of melting rates in the dusted and undusted sections of the river indicated a beneficial effect from dusting. Because of its specific nature and lack of control, the experiment cannot be considered conclusive; it should be repeated with better controls. W68-00048

# THE CONTROL OF GROUND-WATER OCCUR-RENCE BY LITHOFACIES IN THE GUADALU-PIAN REEF COMPLEX NEAR CARLSBAD, NEW MEXICO, Massachusetts Univ., Amherst Ward S. Motts.

Geol Soc of Amer Bull, Vol 79, No 3, pp 283-297, Mar 1968. 15 p, 8 fig, 4 plate, 18 ref.

Descriptors: New Mexico, \*Groundwater, Aquifers, \*geology, \*Limestones, Karst, \*Car-bonate rocks, Caves, \*Groundwater movement, Saline water, Fresh water, Springs, Groundwater Saline water, Fresh water, Springs, Groundwater barriers, Geologic control, Water circulation, \*Hydrogeology, Structural geology, Dolomite, Water table, Zone of saturation, \*Transmissivity, \*Permeability, Structural geology. Identifiers: \*Groundwater occurrence, \*Groundwater discharge, Solution openings, Lithofacies, Impermeable rocks, Low permeability, Evaporites.

Groundwater occurrence and movement in the Guadalupian Reef complex near Carlsbad is controlled by gradual and abrupt changes in lithofacies. Four facies zones have been recognized: (1) a basin facies of low permeability, (2) a high permeability reef-zone, (3) a shelf-carbonate facies ranging from high permeability near the reef-zone to low permeability near the shelf-evaporate zone, and (4) a shelf-evaporate facies of moderate permeability. Permeability is greater in coarsergrained than in finer-grained detrital carbonates and in calcareous than in dolomitic rocks. Facies changes have caused 4 north easterly-trending strips of relatively high transmissivity. In 3 of these zones groundwater drains northeastward and discharges through springs in crosional valleys of Rocky Arroyo and Pecos River. The zones of high permeability result from the solution of carbonate and evaporite rocks: fine-grained dolomitic rocks and carbonate-cemented sandstones form lateral and vertical confining zones. Circulation of water in permeable carbonate rocks has caused development of extensive solution openings, of which Carlsbad Caverns are a part. The presence of fresh water west of Pecos River and saline water in the same rocks east of the river is interpreted to be due to the structural history. W68-00053

# USE OF WATER BY RIPARIAN VEGETATION, COTTONWOOD WASH, ARIZONA, with a section on VEGETATION, by F. A. BRANSON AND R. S. ARO, US Geological Survey James E. Bowie, and William Kam.

US Geol Surv Water-Supply Pap 1858, 62 p, 1968. 17 fig, 1 plate, 10 tab, 5 ref.

Descriptors: \*Transpiration control, Arizona, \*Riparian plants, Vegetation effects, Streamflow, Water utilization, \*Evapotranspiration, Water level fluctuations, Meteorological data, Water quality, Humidity, \*Hydrologic budget, Water loss, \*Surface-groundwater relationships, Alluvium, Solar radiation, Seepwillow, Cottonwoods, Surface waters

Identifiers: \*Groundwater levels, \*Chemical analysis (Water), Defoliation, Vegetation eradication, Water-budget method, Stream channel.

The change in water use resulting from modifica-tion of riparian vegetation was measured. A 4.1-mi reach of stream channel was divided into a 2.6-mi upper and 1.5-mi lower reach. Measurements of streamflow, groundwater levels, vegetation, and

# WATER QUANTITY MANAGEMENT AND CONTROL—Field 04

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meteorological phenomena defined the use of water by the vegetation under natural conditions. Subsequent defoliation and eradication of vegetation in the lower reach permitted determination of the change in water use that resulted from the modification. The transpiration-well and waterbudget methods were used to make the analysis. Before modification, average loss of water in the growing season was 80 acre-ft, about 18% of the flow entering the reach. After modification, the average loss was 42 acre-ft, about 12% of the flow entering the reach. Tables give data on vegetation, hydrology and meteorology, daily flow at gages, daily water levels in wells, and analyses of water samples. A 1:1,200 scale map shows area geology and location of data sites. W68-00061

# TICKFAW RIVER AT STARNS BRIDGE NEAR MAGNOLIA, LOUISIANA,

US Geological Survey. Braxtel L. Neely, Jr. US Geol Surv open-file rep, 7 p, Mar 1968. 3 fig, 1

Descriptors: \*Floodwater, \*Frequency analysis, \*Flow characteristics, Discharge (Water), \*Stage-discharge relations, \*Peak discharge, Floods, Water levels, River flow, \*alteration of flow, Basins, Louisiana, Streamflow, Stream gages, Floodwater, Overflow, River flow, Streams, Gaging

Identifiers: \*Water-surface elevation, Flood elevations, 25-yr flood, 50-yr flood, Flood flows, Flood frequency

The effect of raising the grade of State Highways 441 and 442 on flood-flows in the Tickfaw River at Starns Bridge near Magnolia, La. was analyzed. A flood-frequency relation at the bridge was based on a similar relation for the river at Holden (4 mi downstream) and on the relative drainage areas, above both sites. The discharge expected to occur at Starns Bridge on the average of once in 25 yr is 14,800 cfs, and once in 50 yr, 17,300 cfs. According to a stage-discharge relation developed for the bridge site, the 25-yr flood would have a stage of about 60.4 ft and the 50-yr flood, a stage of 61.0 ft. Under existing conditions floodwater flows over the highway west of the river and under the main channel bridge. After the grade is raised, only 450 cfs will flow over the road during a 25-yr flood (compared with 3,900 cfs under existing conditions) and during a 50-yr flood, flow over the road will be 1,000 cfs (compared with 5,400 cfs under existing conditions). Also, more of the floodwater will flow under the main bridge than at present, and part will flow downstream along the west side of the road and under other bridges. W68-00069

# RATES OF SLOPE DEGRADATION AS DETER-MINED FROM BOTANICAL EVIDENCE, WHITE MOUNTAINS, CALIFORNIA,

US Geological Survey Valmore C. LaMarche, Jr. US Geol Surv Prof Pap 353-1, pp 341-377, 1968. 37 p, 36 fig, 2 plate, 8 tab, 39 ref.

Descriptors: \*Methodology, \*Mass wasting, \*Sediment transport, Slopes, Erosion, Bedrock, Dolomite, \*Weathering, Mudflows, \*Terrain analysis, California, Bristlecone pine trees, \*Geomorphology, Semiarid climate, \*Geology, Sediment load, Environmental effects, Mountains, Topography

Topography.
Identifiers: \*Degradation (Slope), Rock removal, lentifiers: \*Degradation (Processes), \*Erosion references. \*Degradation \*Methodology (Development), Rock debris, \*Tree

A method has been developed for calculating the rate of slope degradation by studying the exposure of roots of ancient bristlecone pines in the semiarid White Mountains of east-central California. The method is based on the shallow root development in young trees and the exposure of roots of older

trees. Local degradational rates are calculated using ages of the trees, based on growth rings, and the depth of root exposure for several trees. Because trees dam debris upstream and hollows form on their downstream sides, care must be used in estimating minimum degradation. Studies over a 20-sq-mi area suggest that degradational rates vary from less than 0.5 ft/1000 yr on gentle slopes to about 4 ft/1000 yr along steep channel banks. A comparative study of 72 dated trees in 2 selected areas showed that a rocky knoll was degraded about 1.2 ft/1000 yr during the past 2,700 yr whereas the rate was only 0.8 ft/1000 yr on a long valley side slope. Similar rates have been estimated comparable areas elsewhere. Weathering products move rapidly on slopes and in stream channels, and cloudburst floods transport coarse sediment and produce mudflows. W68-00071

#### ON FORECASTING LOW-FLOW DELAWARE RIVER,

U S Geological Survey, Water Resources Division, Milford, Pa. Robert E. Fish.

ASCE Proc, J Irrig and Drainage, Vol 94, No IR2, Pap 5978, pp 223-232, June 1968. 10 p, 2 fig, 3 tab, 2 ref, 1 append.

Descriptors: \*Low-flow augmentation, Low flow, \*Delaware River, River forecasting, Delaware River Basin Commission, \*Water management (Applied), Runoff, \*Runoff forecasting, Streanflow, Surface waters, Rivers, River regulation, \*Regulated flow, Discharge (Water), Hydraulics, Droughts, Reservoir operation.

Identifiers: \*Mimimum flows, Reservoir releases, Flow management.

A method is described to design reservoir releases, 3 days in advance, to maintain required low flows on the Delaware River. In 1954 the U S Supreme Court established a minimum flow of 1525 cfs for the river at Montague, N.Y. The method utilizes 6 index stream gages, weather forecasts, estimates of streamflow recession, and anticipated releases from powerplants. When flow from uncontrolled areas and powerplants is estimated to be less than the mandatory minimum, releases are ordered from upstream New York City reservoirs to make up the difference. During the severe drought of 1961-66, storage in the reservoirs was so low at times that diversions to augment low flows were reduced substantially from amounts required to maintain the mandatory low flow. W68-00081

# USING PARALLEL TERRACES, THEY'RE CONSERVING RAINFALL TO SUPPLEMENT IRRIGATION WATER.

Irrig Age, Vol 2, No 11, pp 20-G5 to 20-G6, June 1968. 2 p, 1 photo.

Descriptors: \*Soil moisture, Soil water, \*Infiltra-tion, Moisture availability, \*Water utilization, \*Contour farming, \*Terracing, Land management, Flow control, \*Water spreading, Water control, \*Rainfall disposition, \*Induced infiltration, Soil management, Ponding, Water conservation. Identifiers: Runoff control.

Parallel terraces are being constructed in northwestern Dickens County, in the High Plains of Texas. To build the terraces, soil is usually obtained from the lower side, and the area between the terraces is then levelled. The terraces retain infalling precipitation and allow it to soak into the soil. Those constructed retained as much as 12 in. of rainfall during Aug 1966. Some farmers think crop yields from the terraced fields compare favorably with those from irrigated land. W68-00083

# INTERIOR DRAINAGE FOR HURRICANE PROTECTION PROJECTS,

Turner, Collic and Braden, Inc., Houston.

Donald R. Van Sickle.

ASCE Proc, J Hydraul Div, Vol 94, No HY2, Pap 5858, Mar 1968. 26 p, 13 fig, 8 tab, 19 ref.

Descriptors: \*Drainage engineering, \*Hurricanes, Ponding, Tailwater, Rainfall-runoff relationships, \*Flood protection, Hydraulic structures, Water distribution (Applied), \*Drainage systems, Hydrology, Controlled drainage, Tidal effects, Texas, Hydraulics, Computer programs, Outlets, Flood-ways, Pumping plants, Hydrographs, Storms. Identifiers: \*Interior drainage, Tide stages, Urban hydrology, Port Arthur area, \*Hurricane protection, Design objectives.

Problems of interior drainage in hurricane protection projects are illustrated, and methods of analysis and the solutions obtained are discussed, based upon studies made in the Port Arthur area, Texas. Engineering of the drainage systems involves many aspects of hydrology and hydraulics, including rainfall and tidal studies, urban hydrology, synthetic hydrographs, reservoir routing, pump selection, etc. These procedures are applied to interior drainage design in the low ground elevations and flat slopes of the Gulf Coast, with particular reference to the Port Arthur hurricane protection project. Development of design criteria is described, including hydrograph characteristics, rainfall, tides, and ponding levels. Design procedures, including selection of pump station capacities, gravity outlet sizes, and other project features are summarized. W68-00090

# FLOOD OF JUNE 7, 1967, IN THE WAP-SINONOC CREEK BASIN, IOWA,

US Geological Survey Iowa Highway Commission. Harlan H. Schwob.

US Geol Survey open-file report, 21 p, Jan 1968. 3 fig, 1 tab, 1 append, 1 ref.

Descriptors: \*Peak discharge, Iowa, Flood damage, \*Floods, \*Storm runoff, Elevation, Rainfall-runoff relationships, \*Streamflow, Floodwater, Discharge (Water), Riverflow.

Identifiers: 50 yr recurrence-interval flood, Flood elevation, Streambed elevation.

An outstanding flood occurred in the 180 sq mi Wapsinonoc Creek basin in east-central Iowa on June 7, 1967. The flood resulted from rainfall of 4 to 13 in. in about 14 hr the night of June 6 and morning of June 7. The resulting peak discharges ranged from about 1.9 to 4.3 times the 50 yr recurrence-interval flood. Peak discharge of 27,400 cfs was measured from 161 sq mi of the basin. The peak discharges from drainage areas larger than 40 sq mi were among the greatest recorded in the last 50 yr in eastern lowa. Some highways and buildings were inundated but no human lives were lost. Flood damage was light to crops which were in early growth stages. A map at about 3 mi/in. shows rainfall during the storm by 1 in. isohyets. A table gives the drainage areas, location of flood-discharge sites, flood and streambed elevations, peak flow, and discharge for a 50 yr flood for 48 sites in the basin. W68-00098

## EVAPORATION STUDY AT WARM SPRINGS RESERVOIR, OREGON,

US Geological Survey Oregon State Eng. D. D. Harris.

US Geol Survey open-file report, 17 p, Jan 1968. 7 fig, 2 tab, 5 ref

Descriptors: \*Reservoir evaporation, Evaporation pans, Bank storage, \*Hydrologic budget, \*Mass transfer, Inflow, Oregon.

Identifiers: Water budget method, Outflow, Inflowoutflow relations, Reservoir capacity, Vapor-pressure difference.

The purpose of the study was to test the mass transfer-water budget method of computing reservoir evaporation at Warm Springs Reservoir in east-central Oregon. The reservoir stores water for

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irrigation; therefore, its contents and surface area change greatly from early spring to late summer. This reservoir was chosen for the study because evaporation is a large part (20 percent) of its hydrologic budget. The computed mass-transfer coefficient (for evaporation, in in./day) was 0.0072--about 3 times as large as previously determined coefficients for reservoirs of similar size. The results probably were affected by inaccuracies in the inflow and outflow parts of the hydrologic budget and reservoir-capacity table, the unmeasurable effects of bank storage, and the fact that equipment-operation problems and the remoteness of the area resulted in incomplete records of many hydrologic factors. It is concluded that the technique was not practical for this reservoir. Calibration data are listed in a table and graphs show the relation of water budget evaporation to the quantity of windspeed times vapor-pressure difference. W68-00099

#### PRESERVATION OF SCENIC RIVERS,

Kentucky Univ., College of Law, Lexington. A. Dan Tarlock.

Ky L J, Vol 55, No 4, pp 745-798, 1967. 54 p, 200

Descriptors: Rivers, Recreation, Non-consumptive use, Economic impact, Reasonable use, Riparian rights, Prior appropriation, Scenery, \*Wild rivers, Wild Rivers Act, Federal Power Act, Cost-benefit ratio, Water policy, \*Water utilization, \*Competing uses, Dams, \*Project planning, Water resources development, \*Federal project policy. Identifiers: Free-flowing waters.

In some instances preservation of a river in its freeflowing condition should be its highest use. Existing laws favor short term uses such as flood control and power generation over long term uses such as recreation. The article offers critical evaluation of water law concepts relating to preservation of freeflowing rivers, and suggests modifications of existing doctrines to include preservation values into water use decisions. Included are discussions of existing doctrines of right to free-flow, state preservation legislation, incorporation of preservation values into federal dam construction decisions, and proposed national scenic river programs. At the state level, the article concludes that private law doctrines of water rights (riparian rights and prior appropriation) offer inadequate protection of appropriation) offer inadequate protection of preservation values, and decisions to preserve free-flow should be made by state legislatures or ad-ministrative agencies. Seven criteria necessary for state programs to encourage preservation of free-flowing water are listed. At the federal level, the ar-Howing water are listed. At the lederal level, the article discusses major agencies involved with free-flowing water. Proposed federal legislation is also discussed, and it is concluded tha future decisions should not be made solely on economic criteria. W68-00109

# REAL PROPERTY - RIPARIAN RIGHTS OVERFLOW WATERS,

Gonzaga Law Review Association, Spokane.

Gonzaga L Rev, Vol 3, No 1, pp 245-253, Spring 1968. 9 p, 31 ref.

Descriptors: Flood protection, \*Floodwater, \*Overflow, Water injury, Floods, \*Washington, Water control, \*Water law, \*Floodways, Surface runoff, Surface waters, \*Riparian rights, Riparian land, Embankments.

Identifiers: \*Floodchannel.

There are conflicting opinions in classifying waters that have overflowed the banks of a river or stream. Laws relating to riparian water of those relating to surface waters may be held to be applicable. The majority position is that overflowing waters still remaining within the floodchannel are governed by riparian principles. The minority position is that overflow waters are surface waters. In the majority jurisdictions, a riparian owner cannot embank

against floodwaters if doing so would result in damage to other riparian owners. Minority jurisdictions allow embankment against floodwaters without liability for damages. Some courts designating extraordinary floods; and most of these courts allow embankment against extraordinary floods without liability for resulting damages. The article then comments on an application of these principles by a Washington court in a recent decision.

W68-00118

# SURFACE WATER DRAINAGE IN IOWA. lowa Univ., lowa City.

Iowa L J, Vol 50, pp 818-836, Spring 1965. 18 p, 105 ref. disc.

Descriptors: \*Surface drainage, Civil law, Reasonable use, \*Iowa, Easements, Agriculture, Drainage districts, Damages, Discharge (Water), Natural flow, \*Preferences (Water rights). Identifiers: Common enemy rule.

The three basic approaches in solving surfacewater conflicts are examined: the civil law rule, the common enemy rule, and the rule of reasonable use. As presently modified each of these rules will reach substantially similar results. The second part of the article examines the lowa law on the subject. Case law initially held upper owners liable for any increased quantity or change in the natural flow of water discharged upon the lower owner's land. Subsequent modifications presently hold the upper owner liable for discharge by natural or unnatural means only where the flow is so greatly increased as to be the cause of substantial injury. Present statutes allow individual owners to obtain casements across adjoining property where it can be shown that drainage will be beneficial for agriculture. Drainage districts are authorized upon the petition of two or more landowners. The article concludes with a plea for adoption of one of the three basic approaches, since existing case law is uncertain and statutory law deals only with agricul-W68-00148

# THE CONSTITUTION AND STATE CONTROL OF NATURAL RESOURCES. Harvard Univ., Cambridge.

Harv L Rev, Vol 64, No 4, pp 642-652, Feb 1951.

Descriptors: \*Conservation, Natural resources, Economics, Legal aspects, Government supports, Taxes, Interstate, Legislation, Federal government, \*State governments, Interstate compacts, \*Judicial decisions, Federal jurisdiction, State jurisdiction, Contraints, Political constraints, Regulation, Public benefits, Social aspects.

Identifiers: \*Constitutional law

Federal Constitutional limitations upon state efforts to promote conservation are discussed. The due process and equal protection clauses of the Fourteenth Amendment and the Commerce Clause are the primary limiting provisions. State efforts to promote conservation through nondiscriminatory regulations have generally been upheld by the Supreme Court. The Court has been less sympathetic toward statutes which meet resource shortages by hoarding rather than conserving natural resources. Devices used by the states in attempting to keep their resources within their boundaries are examined. The most difficult of these to attack on constitutional grounds seem to be taxation, subsidization and price regulation statutes. It is concluded that in the absence of Congressional action, states are often powerless to act to conserve natural resources. This creates a gap in conservation legislation. It is suggested in the absence of its own legislation that Congress remove restrictions on state action. Perhaps the alternative would be approval by Congress of interstate compacts to attack the problems on a regional level.

#### RELATION OF CHANNEL WIDTH TO VERTI-CAL PERMEABILITY OF STREAMBED, BIG SANDY CREEK, COLOORADO, IJS Geological Survey

US Geological Survey.
Donald L. Coffin.
U S Geol Surv, Prof Paper 600-B, pp 215-218,
1968. 4 p, 2 fig.

Descriptors: \*Channel morphology, \*Permeability, \*Streambeds, Water loss, Ephemeral streams, Floodwater, Zone of saturation, Precipitation, Vegetation, Saturated flow, Seepage, Recharge, Water table, Hydrology, Geology, Alluvium, Watersheds (Basins).

Identifiers: Big Sandy Creek, Colo.

Big Sandy Creek, a tributary of the Arkansas River in east-central Colorado, the lower 140 miles of which is mostly ephemeral, was studied to determine a method of evaluating the average vertical permeability from relations of decrease in channel width and long term average water loss. Geology, hydrology and vegetation of the drainage basin were discussed. Since the rate of decrease in discharge between two points in the ephemeral reach was governed by vertical permeability of the streambed, the average vertical permeability ould be expressed in terms of changes in channel width, slope, depth, and channel roughness, and distance of the reach from the head of the stream. Measurement and analysis of channel width data afforded a tool to estimate recharge and gave a basis for comparison rates of recharge by ephemeral streams in similar settings.

W68-00304

# 4B. Groundwater Management

# GROUND-WATER RESOURCES OF LIBERTY COUNTY, TEXAS, US Geological Survey.

R. B. Anders, G. D. McAdoo, and W. H. Alexander, Jr.

Tex Water Develop Board Rep 72, 140 p, Apr 1968. 20 fig, 8 tab, 45 ref.

Descriptors: Texas, \*Groundwater, \*Aquifers, \*Water utilization, Water sources, \*Water quality, Water level fluctuations, Irrigation water, Saline water, Hydrologic properties, Transmissivity, Storage coefficient, Water wells, Water yield, Municipal water, Hydrologic data.

nicipal water, Hydrogeology, Confined water, Fresh water, Hydrologic data. Identifiers: Pumpage, \*Groundwater utilization, Water level declines, \*Groundwater availability, \*Chemical analysis (Water), Well data.

In 1965, about 110,000 acre-ft of water was pumped for irrigation—1/2 from the ground and 1/2 from the Trinity River. Irrigation use constituted 95 percent of groundwater pumpage, and 3 percent, about 1.6 mgd, was for public supply. The principal aquifers, Tertiary and Quaternary deposits which crop out in belts nearly parallel to the Gulf coast-line, in places contain fresh water to depths of 1800 ft below sea level. They could sustain pumping at 200 mgd--about 4 times the present rate. The additional water would come from the capture of recharge now being rejected where the aquifers outcrop. Of the principal aquifers—Jasper, Evangeline, and Chicot—the Chicot is the shallowest, and it produced about 40 percent of the groundwater used. Most of the remainder came from the Evangeline. Natural recharge to the aquifers is by infiltration of precipitation. Water moves downdip from recharge areas toward the coast and centers of pumping. Discharge is by pumping, through flowing wells, and from seeps and springs. Maps at about 1:330,000 scale show altitudes on the base of each aquifer, water levels, chemical quality, well depth, base of fresh and slightly saline water, and thickness of sand in fresh- and saline-water zones. Tables give well records, well logs, and chemical analyses of water. W68-00013

WATER-DELIVERY STUDY, LOWER NUECES RIVER VALLEY, TEXAS, US Geological Survey.

Groundwater Management—Group 4B

Sergio Garza. Tex Water Develop Board Rep 75, 63 p, May 1968. 12 fig, 11 tab, 12 ref.

Descriptors: \*Water delivery, Water supply, Hydrologic data, \*Losses (Water), Evapotranspiration, Flow rates, Alluvium, \*Surface-groundwater relationships, Texas, Water table, Fluctuation, Chlorides, Groundwater, Chemical analysis, Temperature, Testing, Hydrographs, Channels.

Identifiers: \*Seepage study, Flow duration, Specific conductance, Test holes, \*Mean discharge, \*Corpus Christi, Chemical qualities.

Results are presented of investigations made in 1966-67 to determine the causes of water loss and increase in mineralization in Nueces River, between Lake Corpus Christi and Calallen dam, 35 mi downstream. Municipal and industrial water supplies for the Corpus Christi area are obtained from the channel lake behind Calallen dam. In the study reach, 2 streamflow stations were installed, 37 test holes were drilled to evaluate hydrologic characteristics of the alluvium, and 3 seepage losswater delivery surveys were made. Main conclusions are: (1) Groundwater in the valley alluvium is in hydrologic continuity with the river, and gains or losses in streamflow or groundwater storage depend largely on river stage and water-table changes caused by seasonal evapotranspiration demands; (2) The quantity of water exchanged usually is small; but maximum rates for short periods can be 15 to 20 cfs; (3) Increases in mineralization of the river water are attributable to oil-field waste waters, gravel washing, and contributions of inferior quality groundwater from the alluvium. How-ever, total dissolved solids increases are small and water quality in the Calallen channel lake is well within the US Public Health Service standards. (12 fig, 11 tab, 12 ref) W68-00024

HYDRAULIC PROPERTIES AND HISTORY OF DEVELOPMENT OF LOWER PENNSYLVANI-AN AQUIFERS,

Federal Water Pollution Control Administration,

Wheeling, W Va. Benton M. Wilmoth.

Proc of West Virginia Acad Sci 1967, Vol 39, pp 337-342, Feb 1958. 6 p.

Descriptors: West Virginia, \*Aquifers, \*Confined water, \*Groundwater, \*Transmissivity, Water utilization, Hydrogeology, \*Storage coefficient, \*Aquifer characteristics, Sandstones, Water sources, Specific capacity, Fresh water, Hydrologic properties, Municipal water, Industrial water, Deep-well pumping, Underground storage, Water wells, Water shortage.

Identifiers: Pennsylvanian aquifers, \* Yield of wells, Bedrock aquifers, Dependable supplies, Ground-

water supply, Groundwater use.

Since 1900 more than 300 communities have developed public water supplies from lower Pennsylvanian sandstone and conglomerate aquifers. More than 90% of the fresh water available in an area in southern and central West Virginia is groundwater. Moderately large supplies usually lie within 200 to 500 ft of the surface. Yields of wells are greater in the valleys than in the hills because the valleys are formed along lines of major fractures. Yields of wells range from 50 to 1,000 gpm and average 200 gpm. Reported shortages generally result from plant or equipment failures rather than basic supply problems. Some wells have failed in the Charleston business section because of the close spacing of wells and concentration of pumping. The total amount pumped in the region increased from 6 mgd in 1890 to 60 mgd in 1950 and decreased to about 52 mgd in 1967. Most of and decreased to about 22 mgd in 1907. Most of the aquifers are confined; they have storage coefficients of .0001 to .001, and transmissivity coefficients of 10,000 to 88,000 gpd/ft. The specific capacities of pumped wells ranges from 4.5 to 120 gpm/ft. W68-00038

WATER WELLS AND SPRINGS IN BORREGO, CARRIZO, AND SAN FELIPE VALLEY SAN DIEGO AND IMPERIAL COUNTIES, CALIFORNIA.

**US Geological Survey** W. R. Moyle, Jr.

Calif Dept Water Resources Bull 91-15, 16 p, Jan 1968. 3 fig, 12 ref, 5 append.

\*Groundwater, Descriptors: \*Water wells, \*Groundwater, \*Hydrologic data, California, Aquifers, \*Water quality, Drill holes, Logging (Recording), \*Water \*Water levels, Geology, \*Chemical analysis, Water table, Data collections, \*Springs, Alluvium, Playas, Water level fluctuations, Groundwater basins. Deserts.

Identifiers: Unconsolidated deposits, \*Well data, \*Chemical analysis (Water), Pumping-test data, \*Drillers' logs, Water-level measurements.

Hydrologic data for about 1,200 sq mi in Borrego, Carrizo, and San Felipe Valleys, in Imperial and San Diego Counties, were collected and tabulated to provide information for planning the development of groundwater. Unconsolidated alluvium, fan, playa, and lake deposits of several ages are the principal aquifers. Tables present (1) descriptive data for about 600 wells and springs, (2) waterlevel measurements for 31 wells for which more than 5 measurements have been made, (3) chemical analyses of water from about 110 wells and springs (1 to 8 analyses from each source), (4) drillers' logs of about 90 wells, and (5) pumping test data for about 200 wells and springs. Maps at scale 1:62,500 show geology and locations of wells and springs. W68-00056

WATER STUDY, GREATER ANCHORAGE AREA, ALASKA--PROGRESS REPORT, 1966-1967,

US Geological Survey.
William W. Barnwell, and Raymond S. George US Geol Surv open-file rep, 42 p, n d. 21 fig, 1

Descriptors: Water sources, Seismic studies, Alaska, \*Water utilization, Surface waters, \*Analog models, \*Confined water, Water quality, Stream gages, \*Surface-groundwater relationships, \*Hydrologic budget, Water wells, \*Sediment discharge, \*Streamflow, Aquifer characteristics, Borehole geophysics, Groundwater, Saline water intrusion, Geology.

Identifiers: Artesian pressures, Electrical resistivity, Glacial aquifers, Test drilling, Aquifer tests, Confined aquifers, Well yields.

This progress report presents compilations of both existing and new data collected during the first year of a 5-yr water-resources study of the Anchorage, Alaska area. Seismic, electrical-resistivity, borehole-geophysics, and remote-sensing methods were used and small-scale maps show where data were obtained. New wells were inventoried and the program to measure flow, chemical quality, and sediment in streams was expanded. Miscellaneous measurements of streams were made to determine gain or loss, and preliminary work was done on a water budget. Maps show artesian pressures in 1956 and 1967 and the change during the interval. An electric analog model is being constructed to aid in analyzing the groundwater flow system and the effects of development. Plans call for drilling to test new groundwater sources and monitor saline encroachment, and for establishment of additional gaging stations. Field tests will be made of aquifers, and the surface-groundwater relationship studied. A 1:120,000 scale map shows geographic features of the area and the locations of stream and meteorological stations. Charts show water use and streamflow. W68-00059

AVAILABILITY OF GROUND WATER IN CHARLES COUNTY, MARYLAND, with a section on the CHEMICAL QUALITY OF THE WATER, by Charles P. Laughlin,

US Geological Survey. Turbit H. Slaughter, and E. G. Otton. Maryland Geol Surv Bull 30, 100 p, 1968. 31 fig, 14 tab, 23 ref.

Descriptors: \*Aquifers, Geohydrologic units, Geologic formations, Water wells, \*Hydrologic properties, Permeability, Safe yield, \*Water quality, \*Water sources, \*Water utilization, \*Water yield, Confined water, Water level fluctuations, Water-resources development, Hydrologic budget, Sedimentary rocks, Shallow wells, Well spacing, \*Groundwater, Geology.

Identifiers: \*Groundwater availability, \*Yield of wells, Iron removal, \*Artesian aquifers, Surficial deposits, Well data, Well interference.

The groundwater resources of a 457-sq-mi segment of the Coastal Plain are appraised. The area has a temperate, humid climate, with about 46 in. of annual precipitation. The extimated use of groundwater in 1962 was about 3.8 mgd. The county is underlain by a wedge-shaped mass of sedimentary rocks ranging in thickness from 600 to 2,000 ft and containing several important aquifers. Potential yield from these aquifers is estimated to be at least 55 mgd, about 3/4 from surficial deposits which support only small-capacity wells. In 5 areas of anticipated future development, available groundwater ranges from 3 to 16 mgd. For optimum development, the water resources will need proper management including spacing of wells to minimize interference. Groundwater is suitable for mo,t uses but locally may require iron removal. Small-scale maps, figures, and charts show geologic, waterquality, and hydrologic data. Tables give well and aquifer data, particularly for the 5 areas studied in detail W68-00066

WATER RESOURCES OF THE SALMON FALLS CREEK BASIN, IDAHO-NEVADA,

US Geological Survey.

G. Crosthwaite.

US Geol Survey open-file rep, 60 p, 1968. 7 fig, 5 tab, 29 ref.

Descriptors: \*Water utilization, Idaho, Nevada, \*Irrigation wells, \*Irrigation water, Confined water, Areal, Discharge (Water), \*Water quality, Groundwater recharge, Drill holes, Percolation, Canal seepage, Water sources, Water yield, Thermal water

Identifiers: Groundwater discharge, \*Chemical analyses (Water), Test drilling, \*Surface water supply, \*Groundwater supply, Salinity hazard.

The surface-water supply averages 107,000 acreft/yr, of which about 76,000 acre-ft is diverted for irrigation, 30,000 acre-ft is lost by canal seepage, and 15,000 acre-ft is lost by percolation to groundwater. The most extensive aquifer is the Idavada Volcanics which yields water from faults, joints, and gravel beds. Small to moderate amounts are yielded by joints and interflow contact zones in basalt flows overlying the Idavada, and by alluvial and windblown deposits blanketing the area. Irrigation from groundwater is economically feasible in only 5 local areas where 17 wells were in use in 1960. About 8,000 acre-ft was pumped in 1960 for all uses. Groundwater recharge to the basin is estimated to be 200,000 to 300,000 acre-ft/yr, most of which discharges northward toward the Snake River. The groundwater has total-dissolved solids ranging from about 190 to 1000 ppm, but the salinity has not affected crops presently being grown. Maps at about 1:250,000 scale show geolowater-level contours, and well locations. Another 12 mi/in. scale map shows isohyets and the area being irrigated. Tables give hydrologic characteristics of rock units, test-hole data, and chemical analyses of ground water. W68-00070

# Field 04—WATER QUANTITY MANAGEMENT AND CONTROL

## Group 4B-Groundwater Management

GROUND-WATER HYDROLOGY OF THE CHAD BASIN IN BORNU AND DIKWA EMIRATES, NORTHEASTERN NIGERIA, WITH SPECIAL EMPHASIS ON THE FLOW LIFE OF THE ARTESIAN SYSTEM,

US Geological Survey. R. E. Miller, R. H. Johnston, and J. A. I. Olowu. US Geol Surv Water-Supply Pap 1757-1, pp 11-148, 1968. 8 fig, 9 plate, 5 tab, 10 ref.

Descriptors: \*Artesian wells, Aquifers, Wet scasons, Recharge, Water yield, \*Withdrawal, Semiarid climates, Water utilization, Dry seasons, Head loss, Hydrologic properties, Corrosion, Confined water, Boreholes, Foreign countries, Hardness (Water), \*Groundwater mining. Identifiers: \*Artesian head, Dry wells, \*Long-term withdrawal, \*Africa, \*Groundwater utilization,

\*Flow life of the artesian system.

25,000-sq-mi area in northeastern Nigeria is discussed. Annual precipitation ranges from 15 in. to 32 in., most falling from June to Sept. The Chad Formation consists of interbedded sand and clay and has water-bearing units termed the upper, middle, and lower zones. The upper zone supplies water to the provincial capital of Maiduguri and to numerous dug wells. The middle zone supplies water to 190 flowing boreholes used for watering cattle in the northeastern half of the area. There the depth to top of the zone ranges from 500 to 1,250 ft and the thickness from 1 to 200 ft. Boreholes yield 50 to 2,000 imperial gph. Boreholes should continue to flow for at least 30 yr if withdrawal is kept to recommended maximum rates of 100 to 5,000 gph and boreholes are spaced 5 to 10 mi apart. In 1965 water use averaged a scant 265 gph/borehole. The middle zone receivers little recharge and is being 'mined.' The upper zone receives a significant amount of recharge near streams. Ground water is hard and somewhat corrosive, but suitable for livestock and village use. Eight maps at 1:1,000,000 scale present hydrologic data for the upper and middle zones. W68-00073

#### DRAWDOWNS DUE TO PUMPING FROM STRIP AQUIFERS,

West Pakistan Irrigation and Power Department Lahore, Melbourne University Parkville S. M. H. Bokheri, J. K. Strachan, and A. K. Turner.

ASCE Proc, J Irrig and Drainage, Vol 94, No IR2, Pap 5981, pp 233-242, June 1968. 10 p, 4 fig, 1 tab, 7 ref, 2 append.

Descriptors: \*Hydraulics, \*Groundwater, Aquifer characteristics, Water sources, Aquifers, \*Water wells, Aquicludes, Confined water, Pumping, \*Drawdown, Mathematical models, Theoretical analysis, Groundwater movement.

Identifiers: \*Drawdown patterns, \*Strip aquifers, Recharge boundaries, \*Membrane analog, Pumping tests, Aquifer boundaries.

Theoretical mathematical solutions are developed for an idealized confined aquifer which has impermeable and recharge boundaries. Side boundaries of strip aquifers may be either impermeable or recharge, and drawdown patterns are dependent on the type of boundary. Theoretical drawdown patterns for each case generally show agreement when compared to patterns observed using the membrane analog and associated equipment. Comparisons were made for axi-symmetric (single) and multiple-central (5) wells. The main limitation on the method is selecting the distance to zero drawdown which is analogous to the radius of the cone of influence for an infinite aquifer. Both the theoretical and analog methods are applicable to certain field problems. With the theoretical method, trail and error solutions generally are necessary. W68-00077

GEOLOGY AND GROUNDWATER RESOURCES OF CASS COUNTY, NORTH DAKOTA, PART 1-GEOLOGY. U S Geological Survey

Robert L. Klausing. N Dak Geol Surv Bull 47, 39 p, 1968. 15 fig, 3 plate, 1 tab, 38 ref.

Descriptors: \*Geology, North Dakota, \*Glacial drift, \*Geologic mapping, Geohydrologic units, Hydrogeology, \*Alluvium, Water sources, Till, Aquifers, Groundwater.

Identifiers: \*Surficial deposits, Glacial Lake Agassiz, \*Buried outwash.

The geology of Cass County, in southeastern North Dakota, is described in sufficient detail to provide a framework for part 3, an analytical report on the groundwater resources. The entire county is covered by Late Pleistocene glacial drift, which ranges in known thickness from 132 to 447 ft. Included are till and stratified drift, as well as deltaic, shore, and lake deposits associated with glacial Lake Agassiz. The areal extent of these deposits and contours on the bedrock surface are shown on maps at scale of 1/2 in./mi. Older till, lake, and outwash deposits are buried beneath the mapped surficial deposits. Buried outwash that underlies about 150 sq mi in the northwestern part of the county is a local source of water. Large quantities of groundwater are withdrawn from outwash in a buried channel west and southwest of Fargo. Most of the exposed surficial deposits consist of mixtures of clay, silt, sand, and gravel forming typical glacial terrain features. W68-00079

# GROUND-WATER RESOURCES OF THE SEVIER RIVER BASIN BETWEEN YUBA DAM AND LEAMINGTON CAYON, UTAH,

U S Geological Survey. L. J. Bjorklund, and G. B. Robison, Jr. U S Geol Surv Water-Supply Pap 1848, 79 p, 1968. 11 fig, 2 plate, 7 tab, 33 ref

Descriptors: Utah, \*Groundwater, \*A \*Water sources, Alluvium, Hydrogeology, \*Aquifers, ogv. \*Water wells, Water level, Fluctuations, Irrigation water, Water utilization, Water quality, \*Artesian wells, Limestones, Water table, Groundwater recharge, \*Surface-groundwater relationships, Seepage,

Confined water.
Identifiers: \*Surficial aquifers, Groundwater supply, Solution channels, \*Bedrock aquifers, Flowing wells, Sevier River Basin.

A detailed study of groundwater hydrology is presented for a 19-mireach of Sevier River Valley. Several larger tributary valley areas are included for a total of about 900 sq mi. Aquifers are alluvial and lake deposits, jointed volcanic rock, and cavernous limestone. The principal sources of pumped water are the alluvium and limestone. Groundwater occurs under both water-table and artesian conditions, and wells flow in several areas. Most recharge is along the mountain fronts where stream cross alluvial fans. Water moves toward the river from higher areas and the river gains from springs and seeps. Large springs near Yuba Dam are linked to sinkholes several mi south that mark solution channels in buried limestone. Those springs contribute about 30 cfs to the Sevier River, which also gains about 5 cfs from bank seepage in Mills Valley. In 1963, springs and seeps discharged about 28,000 acre-ft, and flowing wells, about 3,00 acreft. Those sources supply irrigation water and public supplies for the towns of Levan and Scipio. Pumped wells supply water for domestic, stock, and industrial use, and for Mills. Some of the groundwater is slightly saline, but it is all suitable for irrigation. W68-00086

# BASIC GROUND-WATER DATA FOI SOUTHERN COCONINO COUNTY, ARIZONA, U S Geological Survey.

E. H. McGauock. Ariz Land Dep Water Resources Rep 33, 49 p, Mar 1968. 4 fig, 4 tab, 15 ref.

Descriptors: Arizona, Springs, Spring waters, Water wells, \*Drill holes, Water table, \*Water

levels, Aquifers, \*Water quality, \*Groundwater, Hydrologic data, Data collections, Sampling, Surveys, Groundwater basins, Water sources, Water

table, Chemical analysis.
Identifiers: \*Well data, Spring discharge, Well depth, \*Chemical analysis of water, \*Drillers' logs.

Basic ground-water data are listed for about 10,600 sq mi in southern Coconino County, north-central Arizona. A map, approximate scale 15 mi/in., shows locations of wells and springs and 100-ft contours on the water table. Table 1 gives the aquifer, depth, water level, and other pertinent data for about 640 wells. Table 2 gives location, altitude, source, and discharge for 13 springs. Table 3 gives drillers' logs of 92 wells. Table 4 gives chemical analyses of water from 136 wells and springs. W68-00094

# GROUND-WATER RESOURCES IN CLEVE-LAND AND OKLAHOMA COUNTIES, OKLAHOMA,

US Geological Survey.
P. R. Wood, and L. C. Burton.
Okla Geol Surv Circ 71, 75 p, 1968. 8 fig, 2 plate, 9 tab, 40 ref, 1 append.

Descriptors: Oklahoma, \*Water sources, \*Aquifers, \*Water utilization, \*Groundwater \*Aquifers, \*Water utilization, \*Groundwater recharge, \*Water levels, Water storage, \*Aquifer characteristics, Chemical analysis, Water quality, Water yield, Withdrawal, Geology, Bedrock, Alluvium, Mineral water, Well spacing, Chlorides, Sulfates, \*Groundwater, Water resources develop-

Identifiers: Well depth, Well data, \*Water level fluctuations, Municipal water, Industrial water.

The principal aquifer is Garber Sandstone and Wellington Formation in which fresh water extends to depths of 100 to 1,000 ft. Municipal, industrial, and institutional wells generally are 300 to 1,000 ft deep and yield 50 to 450 gpm. In most places water levels have changed little since 1940, but they have declined unbest will be a 100 ft. declined substantially at Norman and Midwest City. Annual recharge is about 90 acre-ft/sq mi in the outcrop area and totals about 72,000 acre-ft. Groundwater withdrawal through 1959 is estimated at 280,000 acre-ft. In 1963 municipal, institutional, and industrial use totaled 25,000 acreft. Secondary aquifers are terrace deposits and alluvium which supply water for domestic and stock use at many places in the area and locally may yield 200 gpm to wells. Water in the area is suitable for most uses but locally is high in chloride, sulfate, or sodium. The principal aquifer has 50 million acre-ft of water in storage of which 2/3 is available for development. A map at about 1:93,500 scale shows geology and locations of wells. Tables give well data and chemical analyses for all aquifers, and data on aquifer tests, yield characteristics, and pumpage for the Garber and Wellington. W68-00096

## SPRING FLOW INTO THE COLORADO RIVER, LEES FERRY TO LAKE MEAD, ARIZONA,

US Geological Survey. P. W. Johnson, and R. B. Sanderson. Ariz Land Dep Water Resources Rep 34, 26 p, Apr 1968. 5 fig, 3 tab, 7 ref.

Descriptors: Arizona, \*Springs, \*Discharge (Water), \*Seepage, Chlorides, \*Dissolved solids, Colorado River, \*Water quality, Water analysis, \*Base flow, \*Inflow, Leakage, Aquifers, Groundwater, Surface waters, Streamflow, Movement. Identifiers: \*Groundwater discharge, Spring discharge, Chemical analysis (Water).

In the 300-mi reach of the Colorado River, 4 main tributaries and many small seeps contribute spring inflow. On the Little Colorado, Blue Springs issues from the Redwall Limestone and has a nearly constant flow of about 220 cfs--about 160,000 acre/ft/yr. At the main spring opening the water has about 2,300 mg/1 dissolved solids and 800 mg/1 of chloride. On Havasu Creek, Havasu Spring is a se-

# WATER QUANTITY MANAGEMENT AND CONTROL—Field 04

# Groundwater Management—Group 4B

ries of seeps from the Redwall Limestone with a flow of about 64 cfs. On Bright Angel Creek, Roaring Springs issues from solution channels in the Muav Limestone and cascades several hundred ft to Roaring Spring Creek. Electric power generated by the fall is used to pump part of the water several mi and lift it 3,800 ft to supply National Park facili-ties on the north rim of the canyon. The water has about 200 mg/1 idssolved solids. Thunder Springs gushes from vertical walls in the Muav Limestone and falls 300 to 400 ft into Thunder River, a tributary of Tapeats Creek. The report also describes other smaller seeps and inflows. Tables give the discharge measured at 16 inflow sites and water analyses from 35 sites on springs and creeks. W68-00097

GEOLOGY AND GROUND WATER IN LABETTE COUNTY, KANSAS,

US Geological Survey. William L. Jungmann, and Charles C. Williams. US Geol Survey Hydrol Inv Atlas HA-279, 1 p, 1968. 1 map, 2 tab, disc.

Descriptors: Kansas, \*Aquifers, Mineral water, \*Shallow wells, Runoff, Geologic formations, Natural recharge, Specific capacity, Average flow, Water quality, Water sources, Storage coefficient, Permeability, Water yield, \*Geology, \*Groundwater, Water wells.

Identifiers: \*Alluvial aquifers, Aquifer tests, Yield of wells, Neosho River, Consolidated aquifers, No-

flow periods.

The atlas describes the availability of ground and surface water in a county in southeastern Kansas. Consolidated bedrock aquifers generally contain fair to poor quality water at shallow depths. Most wells yield less than 5 gpm, but some yield as much as 40 gpm. Wells drilled more than 1400 ft into Cambrian and Ordovician rocks have yielded highly mineralized water. Unconsolidated alluvial deposits along the Neosho River and other streams are the best aquifers. Groups of wells or collection galleries in these deposits may produce 100 gpm. An aquifer test in a well in alluvial deposits showed a specific capacity of 3.9 gpm/ft, permeability coefficient of 420 gpd/sq ft, and storage coefficient of 20 percent. Based on these values, ground-water storage in the deposits is about 2,000 acre-ft/sq mi.

Average runoff from the county is about 10 in./yr. Discharge in Neosho River at Parsons is about 2,400 cfs and in Labette Creek near Oswego, about 150 cfs. Both streams have experienced periods of no flow. The quality of the surface water is good. A no flow. The quality of the surface water is good. A 1.63,360 scale map shows geologic units, depth to water, and depth, yield, and altitude of wells. Tables give water-bearing characteristics of the geologic units and analyses of water from 76 representative wells. (25 references) W68-00100

GROUND-WATER RESOURCES OF THE JAMES, YORK, AND RAPPAHANNOCK RIVER BASINS OF VIRGINIA, WEST OF THE FALL

US Geological Survey. George D. deBuchananne. U S Geol Surv Hydrol Invest Atlas HA-283, 1 p, 1968. 2 map, 3 tab, 23 ref.

Descriptors: \*Groundwater, \*Water sources, Virginia, \*Water quality, \*Water utilization, \*Carbonate rocks, Industrial water, Municipal water, \*\*Aquifers, Crystalline rocks, Water yield, Geohydrologic units, \*Limestones, Geologic formations, Safe yield, Springs, Groundwater basins, Water supply, Pumping, \*Carbonate rocks, Areal, Water wells.

Identifiers: \*Groundwater availability, \*Groundwater potential, Public supplies, Industrial supplies, Well yields, Solution channels, Saprolite.

The availability, quality, and use of ground water in a 16,700-sq-mi area west of the Fall Line are described and shown on maps at scale 1:500,000. The Valley and Ridge province in the western part

of the area is underlain by folded limestone, dolomite, sandstone, and shale. Water moves freely in solution channels developed in the carbonate rocks, and many wells are highly productive. The Blue Ridge province near the middle of the area is a steep-sided ridge a few mi wide but more than 100 mi long. East of the Blue Ridge, the Piedmont province is a rolling area with deep residual soil that yields only small supplies of water to wells. Total groundwater use is small, less than 26 mgd, 20 mgd of which is in the Valley and Ridge province. Potential yield is about .5 mgd/sq mi in Valley and Ridge province and about .4 mgd in Piedmont. The groundwater is generally good and is suitable for public supplies. In most places, wells yield less than 100 gpm, but several high produc-tion areas are noted. In those areas, wells tap carbonate aquifers or multiple producing zones, are adjacent to perennial streams or springs, are several ft in depth, or have combinations of all these factors. Wells in the Piedmont seldom produce more than 75 gpm. W68-00175

AVAILABILITY OF GROUND WATER IN THE BLANDVILLE QUADRANGLE, JACKSON PURCHASE REGION, KENTUCKY,

US Geological Survey. Arnold J. Hansen, Jr.

U S Geol Surv Hydrol Invest Atlas HA-184, 1 map,

Descriptors: \*Groundwater, \*Aquifers, Kentucky, \*Geologic formations, \*Water wells, \*Sands, Water yield, \*Water quality, Water sources, Iron, \*Nitrates, Dissolved solids, Domestic water, Hardness (Water), Chemical analysis, Temperature, Water supply, Hydrologic data, Water pollution. Identifiers: \*Groundwater availability, \*Chemical quality (Water), Yield of wells, Well data, Soft water, pH.

The availability and quality of ground water, location of aquifers, and physical data for wells are shown on a 1:24,000 scale map. A chart gives the thickness, lithologic description, and hydrologic data for geologic units. Principal aquifers in the area are 5 sands in the Eocene rocks, but the 2 lower sands have not been developed as water sources. Wells in the uppermost sand yield up to 200 gpm. Because the sands in the second unit are erratic, yields of wells are small though adequate for domestic supplies. The third unit is the best aquifer and is capable of yielding up to 500 gpm to properly constructed wells. Groundwater in the area is soft to moderately hard, generally has 65 to 130 ppm dissolved solids, and is of suitable quality for most uses. Locally, high concentrations of nitrate suggest contamination from surface runoff.
The water has a pH of 6.1 to 6.6 and iron content of 0.1 to 4.0 ppm. Temperature of groundwater is 59 to 61 deg F. W68-00176

GROUND-WATER RESOURCES AND GEOLOGY OF THE WIND RIVER BASIN AREA, CENTRAL WYOMING,

US Geological Survey. Harold A. Whitcomb, and Marlin E. Lowry U S Geol Surv Hydrol Invest Atlas HA-270, 13 p, 1968. 1 map, 1 chart, 29 ref.

Descriptors: \*Groundwater, \*Geology, Wyoming, \*Aquifers, Hydrogeology, Water wells, \*Water quality, Geologic formations, Water sources, Groundwater basins, Confined water, Artesian wells, Conductivity, Irrigation water, Domestic water, Stock water, Geologic mapping, Arid climates, Piezometry, Humid climates, Mineral water, Specific capacity. Specific capacity.

Identifiers: \*Areal geology, \*Groundwater resources, Groundwater sources, Wind River Basin, Geologic structure, Specific conductance.

The Wind River Basin is a 12,000-sq-mi area in central Wyoming where climate ranges from humid to arid. The basin, a structural depression uplifted and faulted along the margins, contains several thousand ft of Tertiary rocks. Mountains around the basin are formed by rocks, Precambrian to Cretaceous, which dip beneath the basin. Groundwater occurs under both water-table and artesian conditions. Principal water-bearing units are alluvial deposits and Tertiary sandstones (Arikaree and Wind River Formations), which have the potential to yield large quantities of water at places. The Tertiary Fort Union Formation and several of the pre-Tertiary formations also yield water locally. Quality of the groundwater varies from low in mineral content and suitable for domestic use to unusable for stock supplies. Groundwater locally contains undersirable amounts of dissolved solids, fluoride, chloride, sodium, or hydrogen sulfide. Water in alluvial deposits underlying the Riverton irrigation project area is highly mineralized due to irrigation return flow. Analyses of water are given in a table, and the lithologic and hydrologic characteristics of geologic formations, on a chart. Maps at 1:250,000 show geology, piezometric contours, well data, and specific conductance of water. W68-00180

GEOLOGY AND GROUND-WATER RESOURCES OF FILLMORE COUNTY, NEBRASKA, with a section on CHEMICAL QUALITY OF THE WATER,

US Geological Survey. L. R. Petri, C. F. Keech, and V. H. Dreeszen. U S Geol Surv Water-Supply Pap 1839-L, pp L1-L27, 1968. 5 fig, 2 plate, 3 tab, 9 ref.

Descriptors: \*Irrigation wells, \*Groundwater recharge, Water quality, Water supply, Hydrogeology, Nebraska, Overdraft, Permeability, \*Safe yield, Precipitation (Atmospheric), Quaternary period, Water sources, \*Groundwater mining, Aquifer characteristics, Chemical analysis, Natural recharge, \*Water level fluctuations, Unconfined acuifers aquifers.

Identifiers: \*Agriculture, Pumping, Uncon-solidated aquifers, Water table, \*Sustained yield, Aquifer potential, Water wells, Water level decline.

In Fillmore County groundwater development for irrigation from an aquifer in Quaternary unconsolidated deposits ranging in thickness from 80 to 450 ft has been accelerated in recent years. Withdrawals probably have already exceeded the ability of the aquifer to sustain well yields locally. The saturated section ranges from about 20 to 350 ft in thickness, and the aquifer is replenished mostly from precipitation at an average annual rate of about 1.4 in. Recharge is estimated to be sufficient to sustain the average annual pumpage from 460 evenly-distributed irrigation wells. However, 731 irrigation wells had been installed by 1966, and more were planned for the future. Because the quantity of water pumped per yr exceeds the recharge rate, some of the water comes from storage. Thus, water levels in wells are declining. The rate of decline will increase as groundwater withdrawals increase. 6 geohydrologic maps, scale 1:125,000, show well locations, thickness of the Quaternary deposits, shape of the water table, and water quality. 4 geologic sections illustrate the character and thickness of various formations and units. Chemical quality of the water is described and many analyses are shown in tables. W68-00181

GROUNDWATER--THE PROBLEMS OF CONSERVATION AND INTERFERENCES,

Nebraska Univ., College of Law. Philip C. Sorensen. Neb L Rev, Vol 42, No 1, pp 765-776, June 1963. 12 p, 2 dwg, 7 rcf.

Descriptors: \*Nebraska, \*Hydrologic cycle, \*Water wells, \*Withdrawal, Groundwater, Groundwater mining, Water table, Zone of saturation, Zone of aeration, Geology, Administrative agencies, Regulation, Drawdown, Natural

Identifiers: \*Interference, Groundwater conserva-

# Field 04-WATER QUANTITY MANAGEMENT AND CONTROL

# Group 4B—Groundwater Management

This article's primary emphasis is on Nebraska, but it contains a discussion of the relationship between groundwater, geology, and the hydrologic cycle which is of general application. Groundwater is categorized into two zones--the zone of aeration and the zone of saturation. Wells draw water from the zone of saturation. The top of the zone is the water table. Groundwater moves horizontally by either percolation or underground streams. Pumping from a well creates an inverted bell-shaped depression in the water table. When two such depressions overlap, interference occurs. Groundwater mining occurs when withdrawals from wells exceed recharge, thus lowering the water table. Excessive draw down will affect the flow of surface streams in the area dependent upon groundwater streams in the area dependent upon groundwater for their flow. The article suggests a comprehensive state administrative body, with provision for judi-cial review, to regulate water use, including withdrawal of groundwater. A survey of fourteen western states as to groundwater problems is presented. W68-00226

#### LITTLE CHINO VALLEY ARTESIAN AREA AND GROUNDWATER BASIN,

University of Arizona, Tucson. Harold C. Schwalen. Tech Bull 178, Ariz Agr Experiment Station, Feb 1967. 63 p, 10 fig, 12 tab, 14 plates, 15 ref.

Descriptors: \*Groundwater basins, \*Confined water, Semiarid climates, Water level fluctuations, Logging (Recording), Water temperature, \*On-site data collections, Water quality, Streamflow, Hydrology, Geology, \*Recharge, Runoff, Arizona, Aquifers, Lava, Flow, Valleys, Sampling, Wells, Drilling, Pressure, Chemical analysis, Surveys, Contours, Maps.

Identifiers: Little Chino Valley, Ariz.

A study was made of the Little Chino Valley artesian aquifer which occupies a small portion of a larger, fairly well defined groundwater basin with an area of approximately 215 miles in Ariz. The aquifer formation was found to consist of buried lava flows and associated rocks interbedded in the older valley fill and has limited opportunity for recharge. Climate, streamflow and runoff, and geology of the area are discussed. Data mainly hydrologic in nature was collected over a period of 27 years beginning in 1938. Field investigation included accumulation of well drilling information and well logs, spring water level and artesian pressure measurements, establishment of benchmark or measuring point elevations at well locations, sampling for chemical analysis and temperature measurement, well discharge and computation of specific capacities, crop surveys and accumulation of geohydrologic information. Data and results from these investigations are presented and discussed. Accurate determination of recharge could not be made with current information but total accumulation recharge was estimated at 5,000 (+1,000) acre feet. W68-00257

#### OLD IRRIGATED SOILS OF THE KARA-KUM AND LIBYAN DESERTS,

Dokuchayev Soil Institute, Moscow. N. G. Minasina. Soviet Soil Sci, No 5, pp 523-532, May 1966. 10 p, 1 fig, 6 tab, 23 ref.

Descriptors: \*Irrigated land, \*Soil formation, Soil chemical properties, Soil physical properties, Tropical regions, Groundwater, Drainage effects, Irrigation water, Geomorphology, Soil analysis, Soil gases, Nitrogen, Saline soils, Adsorption, Ion exchange, Carbonates, Weathering, \*Deserts, Mineralogy, Humus.
Identifiers: Kara-Kum, USSR, Libya, Oases, Subtropical regions.

tropical regions.

The article gives a comparative description of the old irrigated soils of the subtropical and tropical zones which form under adequate local drainage conditions with a deep groundwater. The physio-

graphic conditions of the two oases are compared together with the ground and irrigation water, makeup and composition of the soils, mineralogical and chemical composition of the oases soils, humus, nitrogen and the physiochemical properties of the soils. The differences between the oases were caused by the zonal effect. There were great similarities in the formation of the old irrigated soils which were reflected in the structure of the profiles of the soil. W68-00263

WATER RESOURCES OF A COASTAL GROUNDWATER BASIN IN NORTH WESTERN MEXICO PART II--GROUNDWATER SUPPLY AND INCIPIENT SALT WATER INTRUSION, University of Arizona, Tucson.
W. C. Matlock, M. M. Fogel, and C. D. Busch. Turrialba, Vol 17, No 1, pp 105-109, Jan-March 1967. 5 p, 4 fig, 3 tab.

Descriptors: \*Saline water intrusion, Groundwater movement, Coasts, \*Encroachment, \*Ground-water, Water storage, Transmissivity, Hydraulic gradient, Hydrologic budget, Watersheds (Basins), Analytical techniques, Aquifers, Salts, Pumping, Flow nets, Equations, Drawdown, \*Overdraft, Saline water-freshwater interfaces. Identifiers: Hermosillo, Sonora, Mexico.

The quantity of water that can be pumped from an aquifer annually without excessive salt water intrusion, and the existing underground water supply were determined for the Hermosillo, Mexico, coast region. Here the use of groundwater exceeds the average annual recharge. An estimate of the potential water resource of the area was made in terms of aquifer characteristics, average annual recharge and available water in storage. Pump test data showed the specific capacity (gal per minute per ft of drawdown) to range from 25 to 250 with an average of about 100. A flow net analysis was made to determine the direction of groundwater movement and the source of the water supply. An adaptation of the Darcy formula for groundwater flow showed that the alluvial aquifer transmisibility was 500,000 gal per day per ft. A water budget for the area was set up in equation form. The Ghyben-Herzberg equation was used to explain the changes in salt content of the aquifers. Three models gave values for average annual recharge. Salt water is entering the coastal aquifer, probably along a 30 mile front, at a rate of approximately 70 feet per year although higher rates of advance are possible in high permeability zones. Movement of the center of pumping to a location further inland would decrease the salt water intrusion. W68-00268

# WATER RESOURCES OF A COASTAL GROUNDWATER BASIN IN NORTH WESTERN MEXICO PART I--IRRIGATION EVALUATION,

University of Arizona, Tucson. C. D. Busch, W. G. Matlock, and M. M. Fogel. Turrialba, Vol 17, No 1, pp 101-105, Jan-March 1967. 5 p, 5 fig, 5 tab.

Descriptors: \*Coastal plains, Groundwater basins, Crop production, \*Irrigation practices, Soil profiles, \*Irrigation efficiency, Water distribution (Applied), Scheduling, Land management, Water conservation, Evaporation control, Water loss, Evapotranspiration, \*Withdrawal, Economic impact, Furrow irrigation, Permeability, Siphons, Seepage. Identifiers: Hermosillo, Sonora, Mexico, Intake

An investigation was conducted to determine how utilization of the existing water supply and the dependable long term water supply for the area. Field tests were set up to study soil profile, irrigation scheduling, land preparation, crop appearance, advance of irrigation water and the intake rate of water into the furrows. The recommendations were to limit the time the water was on the field to a

maximum of one hour, increase the furrow stream size, reduce field length and to cut off the water when the stream had been in the furrow for one hour or less. Many of the irrigation recommendations and water-use calculations were based on an analysis of soil texture. Savings in water application were possible in 50 percent of the cases. Greater water savings were possible on soils having higher water penetration rates. Compact layers, restricting root growth and water penetration were present in most of the medium and heavy soils. Water savings would result in a reduction of the pumping cost for the area amounting to almost \$900,000. The total potential water saving of 178,000 acre-feet does not represent a new source of water. About 90,000 acre-feet might be saved through reduced evaporation and non-economic evapotranspiration. W68-00269

# THE ROLE OF ADVANCED TECHNIQES OF GROUNDWATER MANAGEMENT IN ISRAEL'S NATIONAL WATER SUPPLY SYSTEM, Tahal--Water Planning for Israel, Ltd., Tel-Aviv.

A. Wiener.

Bull International Ass of Sci Hydrol, Vol 12, No 2, pp 32-38, June 1967. 7 p.

Descriptors: \*Groundwater, \*Water management (Applied), Hydrology, Pressure conduits, resources development, Surplus water, Storage capacity, Pumping plants, Surface-groundwaterrelationships, Political aspects, Groundwater mining, Underground storage, Water requirements, Water quality, Distribution patterns, Geohydrology, \*Water supply. Identifiers: Israel, Water grid.

Israel's national water system is complex and its implementation requires not only a continuous flow of sound data and sophisticated evaluation procedures, but also far-reaching legislative powers. The arguments against groundwater utilization are presented with an examination of opponent views. Israels' experience in the use of groundwater as a source and a storage medium are discussed. A National Water Grid, which included tunnels, pressure pipes, canals and pumping stations, was developed to make it possible to convey the surplus of water in the North to areas of water deficiency in the central and southern parts of the area. An important feature of the Grid was the regulation of 3,000-5,000 million cu m of surface and underground storage capacity. An advantage of a combined system is to expand the qualitative regulation of water. It could be possible to mobilize the vast dilution potential of all the water stored in underground formations to overcome acute but passing salinity problems. W68-00270

INVESTIGATION OF GROUND WATER RADIAL FLOW USING RADIOACTIVE TRACERS, Middle Eastern Regional Radioisotope Centre for the Arab Countries, Dokki, Cairo, U.A.R. I. B. Hazzaa, R. K. Girgis, and K. F. Saad. Bull Int Ass Sci Hydrol, Vol 12, No 3, pp 55-59, Sept 1967. 5 p, 1 fig, 1 tab.

Descriptors: Radioactivity techniques, \*Radioisotopes, Piezometry, Adsorption, On-site tests, Arid lands, Tritium, Wells, \*Groundwater, \*Flow, \*Tracers, Pumping, Porosity, Aquifers. Identifiers: United Arab Republic.

The effective porosity of the water bearing forma-tion using radioactive isotopes in the Wadi El-Natrun area of the United Arab Republic was studied. The radioisotopes used were iodine-131, chromium-51 (EDTA) and bromine-82. Together with each of these isotopes, hydrogen-3 (tritiated water - HTO) was injected simultaneously as a reference for the groundwater tracer. The isotope iodine-131 was the most suitable and convenient tracer for effective porosity determination since the adsorption of the isotope on the water bearing formation particles does not influence their velocity in aquifers under pumping conditions. The iodine-131 was easy to detect, had the additional advantage of being cheap and available and since its half-life is only 8.04 days, it was convenient for field work. The interactions of water and the tracer used depended upon the rate at which the solution passed through the aquifer interstices. W68-00273

A PRELIMINARY INVESTIGATION ON THE MAIN FACTORS AFFECTING SOIL SALINITY AND ALKALINITY IN KAFR EL SHAIKH GOVERNORATE, U.A.R., Cairo University; Ministry of Agriculture, U.A.R. A. Zein el Abedine, A. Fathi, and R. Abbas.

J Soil Sci United Arab Republic, Vol 7, No 1, pp 33-43, 1967. 11 p, 6 fig, 1 tab.

Descriptors: \*Saline soils, \*Alkaline soils, Irrigated land, Arid lands, Groundwater, Electrical conductance, Organic matter, Calcium carbonate, Soil texture. Drainage effects, Saline water intrusion, Surface-groundwater relationships, Hydrogen ion concentration, Salts, Subsurface waters, Clays. Identifiers: United Arab Republic, Nile Delta.

The soil salinity of the perennially irrigated soils of the arid regions of the upper Nile Delta and the Valley was mainly due to high and salty groundwater. The main source of this high groundwater level was the Nile River and its distribution canals. Surface soil samples and underground water samples were analyzed for electrical conductivity, exchangeable sodium percentage, organic matter, calcium carbonate, pH and clay content. The factors of high groundwater level, high groundwater salinity, soil relief, the heavy texture of the soil and restricted drainage all contributed to the problem of soil salinity and alkalinity in the area under study. W68-00282

NOTES ON THE RECLAMATION OF SALT-AF-FECTED SOILS IN THE INDUS PLAIN OF

WEST PAKISTAN International Land Development Consultants, NV., Arnhem, The Netherlands H. Schroo.

Neth J Agr Sci, Vol 15, No 3, pp 207-220, August 1967. 14 p, 1 fit, 6 tab.

Descriptors: Land reclamation, Cultivated lands, \*Saline soils, \*Soil amendments, Reclamation, Al-kaline soils, \*Saturated soils, Irrigation efficiency, Soil chemical properties, Carbonates, \*Drainage, Canals, Groundwater, Water table, Water quality, Calcareous soils, Leakage.

Identifiers: Salinization, West Pakistan, Indus

In the alluvial land along the Indus River and its tributaries, increasing salinization of the land has presented a major restraint to agricultural cropping and to the national production for the people and livestock of West Pakistan. The tremendous expansion of canal irrigation, with a grass area of 38 million acres, has induced a hazardous rise in the groundwater tables caused by increased recharge due to canal leakage and shortage of irrigation water resulting in inadequate leaching. The data indicated that near the soil surface, a distinct shift towards saline-alkali condition was most common. It was due to a relative shortage of divalent cations. The salt accumulation near the soil surface does not cause an increasing incidence of merely saline conditions. When saline-alkali and alkali soil layers are devoid of gypsum or other soluble calciummagnesium salts, soil amendments to activate the solubility of these carbonates to supply the divalent cations were used. Proposals were given to solve this national twin-problem of salinity and waterlogging effectually with the aid of manure amendments and additional water allotments to make leaching possible. In the south where the divalent cation content is high, areas are most easily reclaimed. W68-00296

GROUND-WATER RESOURCES OF THE SEVI-ER RIVER BASIN BETWEEN YUBA DAM AND

LEAMINGTON CANYON, UTAH, Utah State Eng, Salt Lake City, Utah. L. J. Bjorklund, and G. B. Robinson, Jr U S Geol Surv, Water-Supply Paper 1848, 1968. 79 p, 7 tab, 11 fig, 28 ref.

Descriptors: Utah, Groundwater, \*River basins, Groundwater movement, Water table, Discharge measurement, Hydraulic gradient, Flood plains, Confined water, Surface-groundwater relation-Salinity, Sodium, Seepage, \*Reservoirs, Channels, Faults (Geology), Alluvium, \*Sinks, Valleys, Identifiers: Sevier River, Utah.

An investigation of ground water resources was conducted in a segment of the Sevier River basin, Utah including Juab, Round, Scipio, Mills, Little, Dog and Tintic Wash Valleys. The area comprised about 900 sq miles and encompassed a 19 mi reach of the Sevier River between Yuba Dam and Leamington Canyon. Descriptions of ground water movement were given for the valleys under investigation. Sinkholes have been formed in the alluvium in 3 of the valleys by collapse of solution cavities. The Sevier River gained 30 cfs from groundwater discharge between Yuba Dam and Leamington Canyon, the major portion of which was discharged at Molton and Blue Springs. Chemical analyses made on 28 water samples from the valleys revealed 21 were fresh and 8 were slightly saline. When classified for irrigation, most of the water samples were in the low sodium hazard class and in either the medium or high salinity class. It was suggested some water could be salvaged from evapotranspiration through construction of pumping wells that penetrated the underlying aquifers; lowering the water levels, however, would effect the discharge of springs and flowing wells and the discharge of the Sevier River. W68-00301

## 4C. Effects on Water OF Man4s Non-Water **Activities**

GROUNDWATER AND BEDROCK SURFACE SOUTHEASTERN DELINEATION

MICHIGAN, Wayne State Univ Andrew J. Mozola Annual Progress Report on Project.

Descriptors: \*Bedrock topography, \*Glacial over-\*Groundwater pollution, Groundwater levels, Hydrogeology, Geomorphology. Identifiers: Southeastern Michigan, Environmental

Major objective involved is delineation of the preglacial drainage pattern and changes imposed upon this pattern by repeated glaciation in order to provide basic data for future ground-water investigations and development in an eight-county metropolitan area. Existing oil, gas, water well, and test-boring records were used to compile on a county basis, bedrock topography, glacial drift thickness, and water-level maps and revise, whenever possible, existing bedrock and surficial geologic maps. These should be of considerable interest and use to individuals concerned with local or regional planning activities. Present findings indicate (1) bedrock surface (350-400 ft. relief) is a highly dissected one, (2) age chronology of the Pleistocene section (0-500 ft) is essential in difcarved bedrock valleys, and (3) increasing urbanization strongly points to contamination of Pleistocene and Paleozoic aquifers; the former primarily by domestic septic tank concentrations and the latter, particularly in carbonate terrain with shallow overburden, by septic tanks and the induced infiltration of polluted surface waters by heavy groundwater withdrawal.

W68-00189

WATER SUPPLY AND POLLUTION CONTROL ASPECTS OF URBANIZATION,

Duke Univ., Durham, NC. Edward H. Bryan. Law and Contemp Prob, Vol 30, No 1, pp 176-192, 1965. 17 p, 2 tab, 18 ref.

Descriptors: \*Water supply, Inter-basin transfers, Water costs, \*Water pollution treatment, Treatment facilities, \*Urbanization, Water resources development, Water quality, Water purification, Water transfer, Hydrologic cycle.

Ideally, water should arrive at the position of its use in adequate quantity for its intended use. Urbanization in a location where local intercepted water to support this development is lacking must bear the cost of importation of sufficient water. This can create political and legal problems, particularly when water is diverted across major political boundaries. The fixed amount of water resources has only recently been subjected to such intense utilization, due to population increase, concentration of people in urbanized areas, and the gradually increasing use of water on a per capita basis due to industrialization. The quantity of water is inex-haustible provided that the quality of wastewater is sufficiently improved before it is returned to the cycle. Removal of pollution substances from waste-water gets more difficult as urbanization increases, due to larger volumes of waste and passage through successive intakes and outfalls of urbanized areas. Increased urbanization outside of organized water and sewer utilities has caused developers to provide these facilities by private wells and septic tanks. which contribute greatly to the growing problem. Development of technically sound subdivision regulation and enforcement is necessary to prevent further degradation of water supplies. W68-00195

## 4D. Watershed Protection

FLUVIAL SEDIMENT IN THE DRAINAGE AREA OF K-79 RESERVOIR, KIOWA CREEK BASIN, COLORADO.

US Geological Survey. James C. Mundorff. US Geol Surv Water-Supply Pap 1798-D, pp D1-D26, 1968. 26 p, 9 fig, 1 plate, 4 tab, 2 ref.

Descriptors: \*Trap efficiency, \*Detention reservoirs, \*Sediment discharge, Hydraulic structures, Flocculation, \*Aggradation, \*Erosion, \*Deposition (Sediments), \*Reservoir silting, Grading, \*Particle size, Suspended load, Colorado, Sediment load, Sediment transport, Streams, Sedimentation rates, Running waters, Streamflow, Sediments.

Identifiers: Upstream structures, Sediment outflow, Reservoir life

Fluvial sediment in the drainage area of K-79 Reservoir was studied as part of a national investigation of trap efficiency of detention reservoirs. During the study period, precipitation was significantly above normal during 4 yr, below normal 4 yr, and near normal 2 yr. From Aug. 1956 to July 1965, 7.5 acre-ft of sediment was trapped in the reservoir and 2.5 acre-ft was discharged. The efficiency was 75% based on volume, and 83% based on the weight of the sediment. About 80% of the sediment was discharged during 2 periods--3 days in 1957 and 2 days in 1965. Much of the sediment produced in a large part of the basin was trapped in upstream structures and never reached K-79 Reservoir. Flocculation was not a significant cause of sediment deposition because the low mineralization of the water and the short detention time in the reservoir are not conducive to flocculation. A 1:1,200 scale map shows areas of deposition and erosion in the reservoir and a small map shows vegetation in the basin. Tables give monthly and annual summaries of water and suspended sediment discharge at the reservoir and the particle size of suspended sediment in inflow and outflow from the reservoir. W68-00067

# Field 04—WATER QUANTITY MANAGEMENT AND CONTROL

## Group 4D-Watershed Protection

AREAS OF LAND SUBSIDENCE IN CENTRAL CALIFORNIA, COMPACTION OF SEDIMENTS UNDERLYING

US Geological Survey Robert H. Meade.

US Geol Surv Prof Pap 497-D, pp D1-D39, 1968. 39 p, 22 fig, 5 tab, 78 ref, 2 append.

Descriptors: \*Sedimentology, \*Compaction, \*Subsidence, California, Overburden, Particle size, \*Petrofabrics, Montmorillonite, \*Clay minerals, Electrolytes, \*Sedimentary petrology, Physical Electrolytes, \*Sedimentary petrology, Physical properties, \*Void ratio, \*Compressibility, Diatoms, Chemical properties.

Identifiers: Interstitial water, \*Pore volume, Particle sorting, Clay particles, \*Particle orientation, Sediment burial, Sediment compaction.

An increase in the effective overburden load from 3 to 70 kg/sq cm, partly natural and partly man-made, caused a 10 to 15% reduction in volume of alluvial sediments in the San Joaquin and Santa Clara Valleys, California. Other factors, such as size and sorting of particles, complicate the effects. Multiple-regression of pore volume, overburden load, and petrographic characteristics of 20 fine alluvial and shallow-marine sediments from San Joaquin Valley show the pore volume to be most closely related to particle size, diatom content, and the proportion of sodium adsorbed by the clay minerals. Pore volume also may be affected by the large proportion of montmorillonite in the sediments, the variable pH, and the concentration of interstitial electrolytes. For these sediments, petrologic factors completely obscure the effects of overburden load on pore volume. The degree of orientation of montmorillonite particles shows no regular relation to depth of burial of the sediments but is related most consistently to types of deposits and decreases in the order of lacustrine, shallow marine, flood plain, and alluvial fan. The specific sediment properties or environmental characteristics that control orientation have not been identified. W68-00074

# APPRAISAL OF WATERSHED MANAGEMENT PROGRAM IN WIND RIVER BASIN, WYOM-ING.

U S Geological Survey. N. J. King. U S Geol Surv open-file rep, 18 p, 1968. 2 fig, 3

Descriptors: \*Watershed management, Watersheds (Basins), Sediment yield, Sediment control, Channel morphology, \*Channel erosion, Aggradation, Detention reservoirs, Bank erosion, Bank protection, \*Flood control, Flood damage, Erosion control, Sediment load, Streamflow, Geomorphology, Water quality, Erosion, Reservoir silting, Trap effi-

Identifiers: Unit rate of runoff, \*Watershed treat-ment, Channel aggradation, Sediment traps, Chan-nel stability, Peak discharge reduction.

The Interior Department Regional Coordinator requested the Geological Survey to appraise the effectiveness of the watershed program in the Wind River basin and to assess its value over the next 50 yr. The program was to reduce high sediment content of the streams and to prolong the life of Boysen Reservoir. Sediment yield/sq mi ranges from about 0.27 acre-ft on the south and east sides to 0.8 acre-ft in the northeast. Structures built under tt in the northeast. Structures built under watershed programs of BLM and BIA have been from 35 to 100 percent effective in stopping sedi-ment. The structures kept 5,380 acre-ft of sediment out of Boysen Reservoir from 1962-67. Indirect sediment-reduction benefits have resulted from upstream flood control and downstream bank protection. Structures in Muskrat Creek watershed effec-tively controlled the 1962 flood which had a recurrence interval of more than 200 yr. Although structures will lose capacity as they accumulate sediment, they should continue to be effective for the next 50 yr during which nearly 24,000 acre-ft of sediment would be kept out of Boysen Reservoir. The effects on water for livestock and wildlife, on forage production, recreation, etc, are difficult to assess. Sediment kept out of the reservoir by structures and a list of 93 Geological Survey hydrologic stations in the basin are tabulated. W68-00095

#### CIVIL LAW PROPERTY--ALLUVION--DISTIN-GUISHING LAKES FROM RIVERS AND STREAMS,

Kenneth E. Gordon, Jr. La L Rev, Vol 25, No 2, pp 554-558, Feb 1965. 5 p,

Descriptors: Louisiana, \*Accretion (Legal aspects), Boundaries (Property), Lake shores, Lakes, Rivers, Streams, Judicial decisions, Legal aspects, Bodies of water, Geomorphology, Civil

The classification of a body of water as a river, stream, or lake has important consequences in Louisiana property law. Under the Louisiana Civil Code accretions formed successively to any soil situated on the shore of a river or other stream are called alluvion, and belong to the owner of the soil situated on the edge of the water. Since this applies only to rivers and streams and not to lakes, the crucial question has been whether a particular body of water is a lake or a river or stream, and what test should be used to make this classification. Under early decisions a body of water was a river or stream if the water moved and had the power to carry alluvion. In a more recent decision the court went beyond this test and considered other geologi-cal characteristics typical of streams and not of lakes, such as the course of the bank line, peat moss deposits, presence of channels, and lack of wave action. This use of geological characteristics for classification of bodies of water will make such classification much easier than under the earlier tests. W68-00191

## TRANSBASIN DIVERSION OF WATER,

Texas Law Review, Austin W. Corwin, and Larry D. Knippa. Texas L Rev, Vol 43, No 7, pp 1035-1061, Oct 1965. 27 p, 111 ref.

Descriptors: \*Watersheds (Basins), Watersheds (Divides), Watershed management, Texas, \*Interbasin transfers, Water Resources Planning Act, Water supply, Water demand, Water allocation (Policy), \*Water law, Riparian rights, Prior appropriation, Judicial decisions, \*Water policy.

The article, in exploring the nature of restrictions on interwatershed diversions, attempts to determine their effect upon the goal of efficient and equitable administration of water resources. Watershed limitations imposed by the riparian doctrine, which is sometimes combined with the prior appropriation doctrine are discussed. According to the traditional riparian doctrine, stream water may be used only upon riparian land, and riparian land is defined as embracing only land within the watershed. Statutory restrictions of three Western states and the Texas situation are examined. No general federal policy on the protection of watersheds has emerged; the closest approach to a national policy on this subject is a provision attached by a conference committee to the recently enacted Water Resources Planning Act. Legal problems in interstate diversions and factors to be considered in formulating a sound policy of transbasin diversions are analyzed. A permit system is advocated if legislation on transbasin diversions is thought necessary. W68-00213

# SEALING SANDS WITH WATERBORNE BENTONITE,

USDA Soil and Water Conservation Research Division, Reno, Nevada. Myron B. Rollins.

Amer Soc Civil Eng J, Vol 93, No IR-4, Proc Paper 5640, pp 25-44, Dec 1967. 20 p, 3 fig, 13 tab, 34

\*Sealants, \*Sands, \*Bentonite, Descriptors: Permeability, Surface sealing, Earth-water interfaces, Laboratory tests, Economic feasibility, Soil water movement, On-site data collections, Model studies, Seepage, Soil density probes, Expansive clays, Compaction, Sedimentation, Water loss, Head loss, Colloids, Clays.

permeable soils with waterborne Treating bentonite could be a rapid, lowcost sealing method. Sand columns 2 ft long were used to resemble field conditions and to provide an adequate sand depth to determine the extent of clay colloid penetration in 4 standard sizes of sand. Open manometers were installed in the cylinder walls to permit reading of head losses during the sealing process. The head above the sand surface was 3.5 ft. Permeability of sand was tested prior to sealing. Coarser sands showed a continuous drop in seepage rates prior to sealing but the seepage rate of the fine sand remained steady except for a slight dip midway. A high-swelling Wyoming bentonite was used to seal the sands. The bentonite concentration in the water above the very coarse sand was 1.0 percent and the fine sand, 0.25. Most of the seal developed during the first 24 percent hours of sedimentation, especially for the 2 smaller sands. At 60 days of sedimentation, all columns were more than 99.5 percent sealed. Drying will damage a seal of high-swelling bentonite but the response to repeated wetting and drying appears to vary for different sand sizes. A retreatment of the sand columns with waterborne bentonite could be effective in forming a lasting seal. The cost of the seals as applied to the 4 sizes of sand tested is given. W68-00259

INFLUENCE OF PLANT RESIDUE ON SAND FLOW IN A WIND TUNNEL,
Canada Department of Agriculture, Research Station, Swift Current, Saskatchewan. Frederick Bisal.

Canadian J Soil Sci, Vol 48, No 1, pp 49-52, Feb 1968. 4 p, 1 fig, 1 tab.

Descriptors: Soil erosion, \*Wind erosion, \*Soil stabilization, Wind velocity, \*Sands, Stubble mulching, Soil management, Flow control, Sand waves, Tunnels, Model studies. Identifiers: Wind tunnel.

Crop residues, when maintained at the soil surface. can effectively prevent soil erosion by wind. Sand was placed in an open-end tray which fit the bed of a return-flow-type wind tunnel. The rate of flow of the sand was determined at different wind velocities with various rates of standing wheat stubble. The general relationship between the amounts of stubble at the soil surface and sand flow rates tended to be sigmoidal. There was an initial phase when small amounts of stubble had very little effect on soil flow. This phase was followed by a very rapid decrease in flow when additional increments of stubble were added to the surface. With a wind velocity of 10.28 meters per second, small amounts of stubble seemed to increase the rate of sand flow. The method described is practical in establishing the relative effectiveness of various crop residues or different means of incorporating such residues in the control of wind erosion. W68-00278

#### THE ORD RIVER CATCHMENT REGENERA-TION PROJECT,

Western Australia Department of Agriculture, South Perth.

K. Fitzgerald. J Agr Western Australia, Vol 8, No 11, pp 446-452, Nov 1967. 7 p, 1 map, 5 photo.

Descriptors: Watersheds (Basins), Gully erosion, Sheet erosion, Soil types, \*Percolation, Calcareous soils, Bank erosion, Wind erosion, Soil-water-plant

## Sources of Pollution—Group 5B

relationships, Grasslands, Soil erosion, Erosion control, Soil reclamation, Stream erosion, Weathering, \*Erosion, Rainfall, Linestones, \*Grazing, Streams, \*Gullies, Rivers.

Identifiers: Ord River, Australia, Western Aus-

The Ord River erosion area is in Western Australia and the Northern Territory. There are an estimated 1.450 square miles of the 17,800 square miles of the catchment area that are subject to varying degrees of erosion. The soil parent material of limestone, mudstone and siltstone have been weathered into fine textured calcareous soils that are prone to wind and water erosion. The country was originally a grassland and grass-savannah woodland complex. The steeply walled creeks, gullies and rivers are the result of the removal of surface plant cover by continuous, uncontrolled grazing under marginal rainfall conditions (17-18 in) on susceptible soils. Poor water penetration due to wind erosion is one of the major limiting factors to successful reestablishment of grasses on the catchment area. W68-00279

THE ORD RIVER REGENERATION PROJECT, Western Australia Department of Agriculture, Perth.

K. Fitzgerald.

J of Agr Western Australia, Vol 9, No 3, pp 90-95, March 1968. 6 p, 9 photo.

Descriptors: Watersheds (Basins), \*Land reclamation, \*Erosion control, Soil-water-plant relation-ships, Stream erosion, Wind erosion, Runoff, Penetration, Gully erosion, Soil temperature, Soil erosion, Silting, Rainfall-runoff relationships, Windbreaks, Contour farming, \*Stocking, Farm management, Revegetation, Scour, Burning, Droughts, Grasslands.

Identifiers: Australia, Vermin, Ord River, Perennial grasses, Fencing, Precedent-perennial grass.

The removal of vegetative cover by consistent and continuous over-grazing of rangeland by both stock and vermin on susceptible soil types in an area of marginal rainfall (17 to 18 inches) together with fire and drought are the basic causes of the erosion in the Ord River catchment area. The soil erosion tools used were the control of grazing using fencing, large-scale pasture establishment and the control of gullies. Cultural operations were aimed at increasing water penetration, providing a seed bed and reducing wind velocity at ground level. Due to the bare nature of the soil, the excessive run-off, degree of slope and intensive rainfall, all cultural and reseeding operations were done using contour lines. The re-establishment of native perennial species through grazing management since seed was not available in sufficient quantities for large-scale reseeding. Strict, long term control of grazing was essetnial to ensure that an adequate ground cover of perennial species was maintained to minimize future erosion of the susceptible area. With a protective vegetative cover re-established, run-off was reduced, water penetration increased and the scouring effect of both wind and water reduced. W68-00288

# 05. WATER QUALITY **MANAGEMENT AND PROTECTION**

# 5A. Identification **OF** Pollutants

TRACE METAL ACCUMULATION BY ESTUARINE MOLLUSKS,
Northeast Marine Health Sciences Laboratory,
Public Health Service, US Department of Health,
Education, and Welfare, Narragansett, RI. Benjamin H. Pringle, Dale E. Hissong, and Edward

ASCE Proc, J Sanit Eng Div, Vol 94, No SA3, Pap 5970, pp 455-475, Jun 1968. 21 p, 8 tab, 37 ref, 1 append.

Descriptors: \*Trace elements, \*Marine animals, Mollusks, \*Estuarine environment, \*Laboratory Mollusks, \*Estuarine environment, \*Laboratory tests, Intertidal areas, Monitoring, Pollutants, Temperature, Chemical properties, Aquatic life, Public health, Absorption, Sea water, Ecotypes.

Identifiers: \*Environmental system, \*Trace metals, Anatomical uptake, Pollution, Cells, Shellfish, Bio-

sphere, Toxicity, Uptake rates.

Described is a series of studies concerning distribution and concentration of trace metals in marine animals. A number of mollusk species are investigated. Wide variety is exhibited in species ability to take up and concentrate zinc, lead, nickel, cobalt, iron, manganese, copper, cadmium, and chromium within their natural estuarine environment. Uptake rates in a controlled, simulatedenvironment system using various concentrations of lead, zinc, copper, and cadmium indicate that all species studied varied in their selectivity for taking up a particular metal. Rate of uptake and tissue level attained vary with time and metal concentration used. Various concentrations of lead show that of the different anatomical areas, the muscle, mantle edge, mantle, gill, gonad, and digestive gland accumulated increasing tissue levels in the order given. Depletion is a relatively slow process; it varies from species to species as to rate and final tissue concentration. W68-00014

WATER MOVEMENT IN AN UNSATURATED SANITARY LANDFILL,

Drexel Inst. of Technology, Philadelphia, Cornell

Univ., Ithaca, NY Irwin Remson, A. Alexander Fungaroli, and

Alonzo W. Lawrence.

ASCE Proc, Jour Sanit and Eng, Vol 94, No SA2, Paper 5904, pp 307-317, Apr 1968. 11 p, 1 fig, 4 tab. 14 ref.

Descriptors: \*Water pollution, \*Groundwater recharge, Groundwater, \*Seepage, \*Soil moisture, Evapotranspiration, \*Landfills, Drainage, Sanitary engineering, \*Leaching, Water pollution sources, Solid wastes, Wastes, Garbage dumps, Waste dumps, Waste storage, Soil properties, Moisture content, Pollutants, Soil water movement.

Identifiers: \*Unsaturated flow, \*Moisture routing, Landfill management, Leachate, Infiltration capacity, Groundwater contamination.

Contamination of groundwater from leaching of sanitary landfills will become more common as use of this waste-disposal method spreads. An understanding of the moisture regimen of the landfill is basic to a knowledge of the character and quantity of the water-borne contaminants it generates. Moisture-routing methods are extended to provide an approximate method for predicting vertical movement of moisture through a hypothetical landfill. The method is based on climatological techniques of soil-moisture routing and incor-porates the hydraulic characteristics of the unsaturated permeable materials making up the fill and overlying soil cover. Using the method, predictions were made of the effect of emplacement season and initial conditions on the movement of moisture. Results show that the time that elapses before the first leachate appears depends on the season of emplacement and the initial moisture content. Various objectives in landfill-management may be obtained by varying the time of emplacement, initial moisture content, soil cover, and other factors. Tables show moisture routing through the soil and compacted refuse and computation of monthly groundwater recharge. W68-00058

CHLOROPHYLLS IN MARINE PHYTOPLANK-TON: CORRELATION WITH CARBON UP-TAKE,

Washington Univ., Seattle. G. O. Anderson, and K. Banse. Deep Sea Res, Vol 12, pp 531-533, 1965. 3 p.

Descriptors: \*Adsorption, Phytoplankton, \*Chlorphyll, Epilimnion, Hypolmnion, \*Carbon radioisotopes, \*Marine plants.

Correlation coefficients between Carbon 14 uptake and light absorbance at 665 mu of pigment extracts of natural marine phytoplankton populations were as high as between Carbon 14 uptake and chlorophyll alpha content from trichromatic determination, and higher than between Carbon 14 uptake and total chlorophyll content. In marine productivity studies, the determination of chlorophyll alpha among the plant pigments often may be adequate. Subsurface measurements were not used in this study because a report now in preparation shows that shade-adapted populations occur beneath the mixed layer and that they have different Carbon 14 uptake/chlorophyll ratios than the populations of surface waters. W68-00252

#### 5B. Sources of Pollution

GEOHYDROLOGY AND GROUND-WATER POTENTIAL OF LAKE COUNTY, INDIANA, US Geological Survey, Indiana Div. of Water, Indi-

anapolis J. S. Rosenshein, and J. D. Hunn.

Indiana Div of Water Bull 31, 36p, 1968. 12 fig, 6 plate, 3 tab, 22 ref.

Descriptors: \*Aquifers, \*Groundwater, Indiana, \*Glacial drift, Water quality, Dolomite, \*Groundwater recharge, \*Safe yield, Water yield, Seepage, Groundwater movement, Bicarbonates, Sands, \*Hardness\* (Water), Evapotranspiration, Specific capacity, Transmissivity, Water utilization, Confined water, Hydrolog-

ic properties, Hydrogeology.
Identifiers: \*Pumpage, Groundwater discharge,
Hydrologic system, Sand aquifers, Bedrock
aquifers, Sulfates, Yields of wells, Potential Yield.

The groundwater system consists of 3 aquifers, Silurian dolomite, and 2 sand units (1 and 3) in the glacial drift. Present pumpage is about 7.5 mgd--1.4 from the Silurian aquifer, 4 mgd from unit 3, and 1.9 mgd from unit 1. Potential yield is estimated to be 200 mgd--24 mdg from Silurian aquifer, 160 mgd from unit 3, 40 mgd from unit 1. Discharge from the Silurian aquifer is by upward leakage locally and by leakage to underlying rocks. Discharge from the sand aquifers is by evapotranspiration and by seepage to streams, drainage ditches, and Lake Michigan (unit 1). Estimated evapotranspiration in 1960 was 9,248 million gal from unit 3 and 7,400 million gal from unit 1. Recharge is from precipitation and moves through confining layers to the 2 lower aquifers (unit 3 and the Silurian aquifer). Urban and industrial development may have reduced recharge to unit 1 by about 1/2. Water from all the aquifers is hard and locally may contain excessive amounts of dissolved solids, sulfate, or iron. Tables give data on water quality and hydrologic characteristics of aquifers. Maps at scales of 1/4 and 1/2 in./mi show geology, piezometric surface, aquifer transmissibilities, specific capacities and yield of wells, water quality, and depth to aquifers. W68-00052

DOWNSTREAM RIPARIAN RIGHT OF A DOWNSTREAM RIPARIAN OWNER TO ENJOIN UPSTREAM POLLUTION,

Albany Law School. Sholom B. Koplovitz

Albany L Rev, Vol 27, No 1, pp 64-72, Jan 1963. 9

Descriptors: \*New York, \*Riparian rights, \*Impaired water quality, \*Pollution abatement, Judicial decisions, Water pollution, Water pollution control, State governments, Legislation, Riparian Identifiers: \*Injunction, Damage.

# Field 05-WATER QUALITY MANAGEMENT AND PROTECTION

# Group 5B-Sources of Pollution

This comment examines the law of riparian pollution in New York, and determines under what circumstances a downstream riparian owner is entitled to enjoin upstream pollution. Early cases held that a lower riparian owner damaged by upper riparian pollution could obtain damages and an injunction where substantial damage was shown. The New York courts then turned to a test which balanced the extent of plaintiffs' injuries against the inconvenience and expense of defendant in abating the pollution. The New York Court of Appeal, in Whalen V Union Bag and Paper Co, 208 NY 1, 101 NE 805 (1913) abandoned this test and laid down the rule that even though plaintiff's damage was nominal compared with defendant's expense of abating the condition there would be no balancing of the equities to determine the propriety of grant-ing an injunction. The New York Water Pollution Control Law of 1961 provides penal and injunctive remedies enforceable by the state, in addition to existing common-law remedies. In New York injunction will lie even if plaintiff's damage is nominal compared with defendant's expense of abating the condition. W68-00220

## 5C. Effects of Pollution

# INTERTIDAL COMMUNITIES AS MONITORS

OF POLLUTION,
Washington Univ. Dept. of Civil Engineering. R. T. Oglesby, and David Jarmison. ASCE Proc, J Sanit Eng Div, Vol 94, No SA3, Pap 6008, pp 541-550, Jun 1968. 5 fig, 14 ref, 1 append

Descriptors: \*Pollutants, \*Estuaries, \*Tidal waters, Ecosystems, Estuarine environment, Marine algae, Salinity, Temperature, Monitoring, Aerial photography, Infrared radiation, Dye releases, Beaches, Sands, Biota, Waste water (Pollution), Currents (Water).

Identifiers: \*Intertidal communities, \*Waste discharges, Flora, Fauna, \*Biological communities, Intertidal algae, Puget Sound, Flourescein dye.

Ecological surveys of intertidal zones are proposed to be the most economical way to assess the biologic impact of many wastes discharged into estuaries and coastal marine environments. Species diversity and community structure are the measures selected; these are determined through a carefully designed and statistically valid program of sampling. Aerial photography is used in developing the sampling program with infrared Ektachrome film providing data on distribution and, to some extent, the nature of intertidal flora. Dye tracers in the effluent are imaged, on time-sequence, color aerial-photographs, and provide information on patterns of waste dispersal. The methodology proposed is applicable only where either spatial or temporal controls can be established. W68-00010

# THE BOTTOM FAUNISTICAL LAKE TYPE SYSTEM AND ITS APPLICATION TO THE SOUTHERN HEMISPHERE,

L. Brundin. Verh int Verein theor ungew Limnol, Vol 13, pp 288-297, Jul 1968. 10p.

Descriptors: Lakes, Profundal zone, Glaciation, \*Aquatic populations, \*Oligotrophy, Eutrophication, Colloids, Nutrients, \*Phosphorus, \*Diatoms, \*Nutrient requirements, Mineralogy, Antarctic, Glacial drift, Classification bibliography. Identifiers: \*Glacial lakes, Mesotrophy, Tanytar-sus, Strictochironomus, Heterotrissocladius, Plumosus, Bathothilus, Orthocladius, Sergentia.

The author reviewed the lake system proposed by Naumann and Thienemann in 1920 as based on bottom fauna of which they identified 2 types, the Tanytarsus and the Chironomus. The more detailed system of Lenz (1925 and 1936) in which was recognized the oligotrophic type (Orthocladius and Tanytarsus lakes); mesotrophic type (Strictochironomus and Sergentia lakes); and eutrophic type (Bathothilus and Plumosus lakes) is described. Chironomus anthracinus larvae seem to dominate the profundal zone of moderately eutrophic lakes and C. plumosus dominate the strongly eutrophic lakes. In studying the bottom faunas of lakes where one or more glaciers form part of the shore, the author found a high incidence of Heterotris-sociadius subpilosus. There were 2000-4000 individuals m, about 10 times the population of a normal lake. The number of organisms seem to be related to the abundant nutrients contributed by the glaciers, particularly to the phosphorus in mineral colloids. Phosphorus supplied by earlier glaciers may have been important in limnic environments in Antarctic waters and in those associated with Pleistocene glaciers. The author cities Fratja (1951), who showed a diatom maximum during the Ice Age. Glacial erosion may thus supply certain nutrients to the lakes. W68-00085

#### POLLUTION--RECOVERY OF STREAM DAMAGES.

Iowa Univ. College of Law, Iowa City.

Iowa L Rev, Vol 50, No 1, pp 141-157, Fall 1964. 17 p, 111 ref.

Descriptors: Beneficial use, Competing uses, Reasonable use, \*Civil law, Appropriation, Easements, Eminent domain, Public rights, Legal aspects, Natural flow doctrine, Prescriptive rights, \*Riparian rights, Riparian land, Third party effects, \*Water law, Water rights, Legal aspects, \*Water pollution, Water pollution control, \*Remedies.

A survey of the tort remedies available to a riparian owner for damages resulting from stream pollution is presented. Tort recovery is based upon nuisance. Liability for niusance may arise from negligent, intentional or abnormally dangerous conduct. When the interests of the public as a whole are damaged, there is a public niusance, but a private party can bring the action if special damage is shown. Independent tortfeasors can only be held liable to the extent that their activity has contributed to injure the plaintiff. Some states provide for joint liability even in the absence of a concert of action. Defenses include the statute of limitations, prescription, a justification on the basis of serving a public purpose, and agreement. It is concluded that commonlaw tort liability has been an ineffective measure for controlling pollution. On the other had, tort liability for injuries may act as a deterrent and can serve to compensate an injured party. Tort liability is considered compatible with statutory controls. W68-00119

#### LAKE EUTROPHICATION PROBLEM AND PROGRESS,

South Dakota State Univ., Brookings.

Min 152nd Mtg, Mo Bas Inter-agency Comm, Append F, pp F-1/F-6, Mar 1968. 4 ref.

Descriptors: \*Eutrophication, Sequence, Lakes, Chemicals, Fishing, Sport fishing, Recreation, Silt, Nutrients, Aquatic populations, Oligotrophy, \*Fish Nutrients, Aquate populations, Bough fish, populations, Plant Populations, Rough fish, Nitrogen, Phosphorus, Diatoms, \*Algae, Chlorophyta, Cyanophyta, Land management, Water pollution sources, Dredging, \*Pollution abatement, Dikes, Soil conservation. Identifiers: Desmins, Flagellates.

The substantial inflow of silt and nutrients causes a lake to age rapidly and to move from oligotrophy to eutrophy and so affect the game-fish population. The addition of nitrogen and phosphorus causes lakes to change from one only sparsely populated, mostly by desmins, to one in which diatoms replace the desmins, these in turn replaced by flagellates and green algae, and finally by blue-green algae, alarmingly in tremendous 'blooms'. The zoological sequence is from the generally oligotrophi trout lakes, to the lakes populated by bass, pike, perch, and panfish, to the eutrophic population of rough fish. Most of the causative nutrients are the result of agricultural pollution resulting from poor land practices and livestock feedlot operations. Once there is eutrophy, remedies are expensive, such as efforts to dilute the lake by dredging or diking. The control of inflow of harmful nutrients and silt can be done inexpensively, as by initiating soil conservation practices and by treating domestic and industrial sewage. Control by harvesting algae is not within reach as yet but fish can be harvested and marketed economically to reduce the total amount of nutrients in the water. Control best starts with lakes in early eutrophy. W68-00172

#### LEGAL IMPLICATIONS OF BOUNDARY WATER POLLUTION, New York State Univ. School of Law, Buffalo.

J. P. Enichesen-Brown Buffalo L Rev, Vol 17, No 1, pp 65-69, Fall 1967. 5 p, 13 ref.

Descriptors: Public health, \*Water pollution, Water pollution control, \*Treaties, Boundary disputes, \*International commissions, Federal government, \*International Joint Commission, International law.

The problem of boundary water pollution between the United States and Canada was just confronted in 1909 by the Boundary Water Treaty, which created the International Joint Commission with representatives from both countries. The Treaty provides that boundary waters shall not be polluted to the detriment of the other side. However, the IJC has used this provision as a basis for research rather than claim settlement. IJC effectiveness has been enhanced by cooperation with local officials. To illustrate the modus operandi of the IJC, the author poses a hypothetical claim of injury by a US citizen as a result of Canadian pollution. The US would present the Canadian government with a claim in its own name. Canadian officials might forward the claim to the IJC. An investigation would follow resulting in recommendations. While the recommendation is not binding on the Canadian government, it might be influential in their decision. The author also believes air pollution could be incorporated into the water pollution provisions. It has also been the duty of the IJC to consider the meaning of the word injury. The author also notes the access of citizens of both countries to each other's courts in disputes over temporary and demonstrable discharges of pollutants. W68-00215

# SOME NATURAL ASPECTS OF EUTROPHICA-

US Geological Survey, Fort Wayne, Indiana.

OS Geological Survey, Fore Wayne, Indiana.

R. G. Lipscomb.

Min 152nd Mtg, Mo Bas Inter-agency Comm,
Bismarck, N Dak, Append H, pp H-1/H-5, Mar
1968. I ref, gloss.

Descriptors: \*Eutrophication, Aging, Wastes, Waste disposal, \*Nutrients, Growth rates, Lakes, Oligotrophy, Dissolved oxygen, Carbon Oligotrophy, radioisotopes, \*Classification, Limnology, Environmental effects, Chemical properties, lced lakes, Photosynthesis, \*Thermal stratification, Seasonal, Annual overturn, Respiration, Decomposing organic matter, Epilimnion. Identifiers: Metalimnion.

The process of lake aging has been altered by discharging wastes to them, thus accelerating eutrophication alarmingly in some lakes. Aging, a natural response to ecological succession as determined by the environment of the lake, ranges from high productivity. There is no single index to the definition of the stage in eutrophication; attempts to find indices include the use of the dissolved oxygen curve and the Carbon-14 method. Now efforts are being made to use 'indicator species.' Limnologists have learned that nutrients such as carbon

# WATER QUALITY MANAGEMENT AND PROTECTION—Field 05

Effects of Pollution—Group 5C

dioxide, becarbonate, iron, molybdenum, calcium, magnesium, silicon, and sodium are important factors in eutrophication in addition to, and locally more important than, the phosphorus-nitrogen content of the water. Different parts of a lake may go through various eutrophication stages within a year. Thermal stratification is related to seasons, witness the effect of a winter ice cover, and the 'overturning' of lake waters. Photosynthesis and respiration greatly affect amounts of dissolved oxygen and carbon dioxide in the epilimnion, respiration and decomposition are major mechanisms in the metalimnion; and decomposition is the important factor in eutrophication in the hypolimnion. W68-00246

#### EUTROPHICATION OF THE ST. LAWRENCE GREAT LAKES,

US Bureau of Commercial Fisheries, Ann Arbor,

Alfred M. Beeton.

Limnol Oceanogr, Vol 10, pp 240-254, Jul 1968.

Descriptors: \*Great Lakes, \*Fish populations, \*Eutrophication, \*Chemical properties, Nutrients, Lakes, Dissolved solids, Oligotrophy, Summer, Classification, Lake Huron, Lake Michigan, Lake Superior, Lake Ontario, Lake Erie, Dissolved oxygen, Hypolimnion, Plankton. Identifiers: \*Accelerated eutrophication, Man's ef-

fects, Mesotrophy.

Lakes Huron, Michigan, and Superior are classified as oligotrophic lakes on the basis of their biological, chemical, and physical characteristics. Lake Michigan trends toward mesotrophy as shown by the high content of dissolved solids in its waters. Lake Ontario is mesotrophic in that it retains the biota of an oligotrophic lake because of its large deep-water area but has the nutrient richness of a eutroic lake. Lake Erie, the most productive of the lakes and the shallowest, is eutrophic. Several changes commonly associated with eutrophication in small lakes have been observed in the Great Lakes, changes that apparently reflect accelerated eutrophication in the Great Lakes because of man's activity. Chemical data compiled from numerous sources, dating back to 1854, indicate a progressive increase in the concentrations of major ions and total dissolved solids, particularly chlorides and sulfates, in all of the lakes except Lake Superior. The plankton has changed somewhat in Lake Michigan, and the plankton, benthos, and fish populations of Lake Erie now differ greatly from those of the past. Recently an extensive area of hypolimnetic water of Lake Erie has developed low dissolved-oxygen concentrations in late summer. W68-00247

# PROPORTIONALITY IN WATER POLLUTION.

G. Akerlindh. Acta Limnol, No 2, 34 p, 1949.

Descriptors: \*Eutrophication, Streams, Lakes, Self purification, Water pollution, \*Environmental sanitation, \*Oxygen requirements, Sewage effluents, \*Water pollution effects, Water pollution control, Oxygen sag, Human population, \*Water purification, Human diseases, Future planning (Projected), \*Estimating equations. Identifiers: Streeter and Phelps formula 1929, \*Lake pollution, \*Stream pollution.

The author examined the pollutional loads of streams and lakes and concluded that the reactions of the recipient water body could be predicted with knowledge of the amount of the incoming load of pollutants. Estimates in some cases, but not in all, can be based upon the Streeter and Phelps relationship (1929, modified): L sub p = L sub h X D sub p/D sub h, in which L sub p = the oxygen demand (the self-purification capacity), L sub h % initial pollution, D sub p = permissible oxygen deficiency, and D sub h = the oxygen deficiency, and D sub h = he oxygen deficiency per initial pol-lution. Direct determination of the amount of the initial permissible oxygen demand cannot be made

when the load of pollutants is altered. The same proportionality prevails in lakes in that the oxygen deficiency is determined by the amount of pollutants added in a unit of time. One type of pollution is a direct menace to health, and the other results in various kinds of nuisances. The burden imposed by increases in human populations may require increasingly accurate predictions as to the 'safe' pollutant loads that can be carried in lakes and streams. Attention must be given to the undesirable effects of nutrients, and to the concept of total suppression of water pollutants.

W68-00249

PALEOLIMNOLOGY,

Wisconsin Univ., Madison; US Geological Survey.

W. H. Bradley. Limnology in North America, D. G. Frey (editor), pp 621-652, 32 p.

Descriptors: \*Geologic history, Aquatic life, \*Sediments, Hydrogeology, \*Eutrophication, Lakes, Mineralogy, Classification, Water chemistry, \*Great Salt Lake, Saline lakes, Geologic formations, Paleolimnology, Oligotrophy, Lake basins, Lake stages, Clays, Logging (Recording), Ecology, Aquatic animals, Carbonates, Reviews.

Identifiers: Lake Bonneville, Utah, \*Green River Formation, Searles Lake, Calif, Flagstaff Lake, Ariz, Sake San Augustin, N Mex.

Valuable historical data on eutrophication and oligotrophication can be gained through the study of lake sediments. The changes in Utah's Lake Bonneville, once a freshwater lake with a surface area of 19,750 sq mi and a depth of 1,050 ft, are described. Studies of Lake Lahontan, Great Salt Lake, The Green River Formation (largely deposited on the floor of a lake that in the geologic past covered much of southwestern Wyo, northwestern Colo, and southeastern Utah), Flagstaff Lake, and the detailed analyses of Searles Lake, Calif, and Lake San Augustin, N Mex, are among those cited by the author. He reviews the work of Eardley et al (1957) and Eardley and Gvosdetsky (1960) on Lake Bonneville sediments: Examination of a long core revealed no single feature plainly diagnostic of deposition in fresh or salt water or in deep or shallow water; rather their conclusions as to the Pleistocene history of this ancient lake were based upon appraisals of several factors used in combination, such as: the content of clay minerals; carbonate content; and the occurrences of oolites, brine shrimp, fecal pellets, and mollusk and ostracod shells. The basic ecological interpretations were made by experts in the several specialties. W68-00250

# THE ROLE OF AGRICULTURE IN THE EUTROPHICATION OF NATURAL WATERS (SWEDISH),

Institutionen for Landbrukets Hydroteknik, Uppsala, Sweden.

NILS Brink

Nord JordbrForsk, Vol 47, pp 197-207, 1965. 11 p, Norwegian Colloq on Prob of Eutrophication, Blin-dern 9-10, Dec 1964.

Descriptors: \*Eutrophication, Sampling, Sweden, \*Watersheds (Basins), Phosphorus, \*Sediment transport, Nitrogen, Human population, Seasonal, \*Agricultural watersheds, On-site data collections, Fluctuation, Environmental effects, Statistics, \*Water quality.

The nutrients were monitored at a series of sampling stations established in a drainage basin in Sweden. The transport of phosphorus was highest during May, the same period in which most soil transport took place. The annual fluctuation in nitrogen was relatively small. The nitrogen/phosphorus ratio increased from 24 to 51 where there was little effect of civilization, and decreased to 9 to 19 where the influence of civilization was strong. This indicates that the more important role is played by phosphorus, if it is assumed

that the concentration of nitrogen remains the same and that of phosphorus increases. However, the situation may be reversed: a decreased concentration of nitrogen and a relatively stable concentration of phosphorus would give a lower ratio, too. The data indicate that the nitrogen/phosphorus ratio was lowest in areas most strongly affected by civilization. W68-00251

# INDICES OF GREAT LAKES EUTROPHICA-

TION, A. M. Beeton.

Publ Great Lakes Res Div, (in press), Vol 14, 1966.

Descriptors: \*Eutrophication, Nutrients, Nitrogen, Phosphorus, Plankton, Dissolved oxygen, Hypolimnion, Great Lakes, Lake Erie, Statistics, Growth rates, Algae, Fresh water fish.

Indices of eutrophication were cited: (1) increases in nitrogen and phosphorus; (2) changes in species composition and an increase in the abundance of plankton; (3) decreases in the dissolved oxygen content of bottom waters; (4) changes in the fish population; (5) the replacement of Bosmina coregoni by B. longirostris; and (6) extensive growths of Cladophora. Other changes such as increases in TDS and major ions are regarded as representative of environmental changes and not necessarily indices of eutrophication. There are few offshore data on nutrients (nitrogen and phosphorus) from the Great Lakes other than Lake Erie, and even these data are questionable. Changes in the rates of growth of fish should be viewed with caution when relating them to eutrophication inasmuch as many environmental variables may be of influence as well as an increase in nutrients. W68-00253

# PLANKTONIC ALGAE AS INDICATORS OF LAKE TYPES, WITH SPECIAL REFERENCE TO THE DESMIDIACEAE,

Minnesota Univ., Minneapolis.

A. J. Brook Limnol Oceanogr, Vol 10, pp 403-411, 1965. 9 p.

Descriptors: \*Eutrophication, Aquatic algae, \*Lakes, \*Classification, Desmids, Oligotrophic, \*Phytoplankton, British Isles, Bioindicators, \*Estimating equations, Period of growth.

After reviewing the work of Nygard (1949) on the 'quotient system' of lake classification, the author describes the use of desmids as indicators of lake types. Nygard states that quotients can only be determined from samples collected during the time of greatest algal development, from mid-May through Sept. A big problem appears to be the correct identification of all of the plankton species. Nygard's 'compound quotient' (1949 and 1953) is: Myxophyceae + Chlorococcalea + Centrales + Euglenineas/Desmidiaceas. Slight errors in determining the number of desmids will alter greatly the dimensionless numbers derived from the quotients and thus will bias the investigator as to the trophic status of the lakes. Eutrophic waters sometimes contain as many phytoplankton species as do oligotrophic waters. In the author's opinion, the composition of the phytoplankton is not necessarily altered by an increase in nutrients; further, that a bloom may not form if the increase in nutrients is a very slow one. A study of 300 lakes in the British Isles indicates that desmids are most common (59 percent) in oligotrophic waters, but are not limited to them; they occur, also (24 percent) in waters classed as eutrophic and having quotients of 2.0 or more. W68-00255

A SYNERGISTIC APPROACH TO PHOSPHORUS REMOVAL,
Dorr-Oliver Inc, Stanford, Connecticut.
Robert J. Sherwood.
J of Civ Eng, Am Soc Civ Eng, pp 32-35, May 1968. 4 p, 3 fig, 1 tab, of ref.

# Field 05-WATER QUALITY MANAGEMENT AND PROTECTION

# Group 5C-Effects of Pollution

Descriptors: \*Eutrophication, Sewage, \*Phosphorus, Phosphates, \*Sewage treatment, Domestic wastes, \*Algae, Water properties, Biochemical oxygen demand, \*Bacteria, Activated sludge, Iron compounds, Lime, Oxygen, Tertiary treatment, Cost comparisons.

The phosphorus in sewage has been held responsible for the excessive algal growths in lakes into which domestic sewage is discharged, but the extent to which it must be eliminated is not known. The design factors in a phosphate-removal plant are: the ratio of soluble to total phosphate; water alkalinity and hardness; BOD removal required; phosphorus removal required; and the ratio of soluble BOD to total BOD. The biochemical removal of phosphorus from wastes by the activated sludge method is effective in certain ratios of influent BOD to phosphorus. The removal rate is high when the sludge age is 0.5-1 day, but is greatly reduced when the age is 15-25 days. Algae can help in sewage stabilization in this cycle: algae produce oxygen which combines with organic matter; this, by bacterial action releases carbon dioxide, ammonia, phosphate, and water, which are then used by the algae to produce more oxygen. Tertiary treatment by the addition of chemicals is effective, but its expense increases greatly after the initial phosphorus removal by the first applied doses. Lime is a less expensive additive than alum or an iron salt and is also effective in primary phosphate coagulation. W68-00256

## 5D. Waste Treatment Processes

#### REMOVAL OF ALGAL NUTRIENTS FROM RAW WASTEWATER WITH LIME,

Metcalf and Eddy, Boston, Mass. J. C. Buzzell, and C. N. Sawyer.

Water Poll Control Fed Jour, Vol 39, No 10, R16-R24 Oct 1967

Descriptors: \*Activated sludge, Algae, Eutrophication, Lime, \*Nitrogen, Hydrogen ion concentration, \*Phosphorus, Sewage treatment, \*Oxidation lagoons.

Identifiers: \*Nutrients, Ponds, Primary treatment, Secondary treatment, Stabilization ponds, Sewage lagoons.

A laboratory evaluation of the application of lime to raw domestic wastewater as a means of enhancing the effectiveness of primary treatment, specifically to reduce phosphorus levels. Lime treatment effected an 80- to 90-percent removal of total phosphorus, with greater than 97-percent removal of soluble, inorganic forms. Lime treatment removed 50 to 70 percent of the BOD, approximately 25 percent of the ADD, approximately 25 percent of the ADD. mately 25 percent of the total nitrogen, and destroyed 99.9 percent of the coliform bacteria. Lime dosage was controlled by pH. The volume of sludge produced was approximately 1 percent of the volume of wastewater treated. The lime treatment effluents had nitrogen: phosphorus ratios of 25:1 or greater. Preliminary studies indicated that stabilization ponds should serve well in polishing the lime-treated wastewater, removing 75 to 80 percent of the remaining phosphorus. W68-00012

#### COSTS DIVE AS WEIRTON RE-USES MILL ROLL COLLANT.

Steel, Vol 162, No 24, pp 78, 80, June 10, 1968. 2 p, 1 illus.

Descriptors: \*Water reuse, Potable water, \*Cost comparisons, Water costs, \*Coolants, Filtration, Comparisons, water costs, \*Coolants, Filtration, Steel, Oxides, Sludge, Pollutants, Temperature, Heat transfer, Surface waters, Consumptive use, West Virginia, Quality control. Identifiers: \*Cooling systems, \*Rolling mills, Surface water source, Contaminants, Vaccuum clean-

ing, Recirculating water.

Described is National Steel's Weirton Steel Division plant, West Virginia. It uses potable water to cool mill rolls and is saving money and water while maintaining quality control standards. A recirculating system with vaccuum filters replaces the old coolant system of water and oil directly applied to the rolls. The old system with continuous disposal of fines and oxides and other contaminants is replaced by 8 filters. Each pair of filters handles 3000 gpm, but in emergencies 1 filter can handle the flow. Because of constant flow of fresh uniform coolant can now be delivered, the need for large storage tanks is eliminated. Formerly, the plant consumed 30 mgd of river water. Losses of oil and necessary chemical water treatment cost \$1 million a yr. Variations in river water temperature caused problems in quality control of product. Only 50,000 gpd are used with the new system and fluid losses occur only through evaporation and leakage. Costs have been cut to \$1.50 per hour per rolling mill for each set of 4 filters.

# PROGRESS REPORT: 10 YEARS OF FEDERAL POLLUTION CONTROL AID, McGraw-Hill, Inc, New York, NY.

Joseph A. MacDonald.

Engineering News-Record, Vol 117, No 12, pp 24-27, Sept 1966. 4 p, 2 chart.

Descriptors: Scwage treatment, Pollution abatement, \*Water pollution control, \*Sewage treatment, \*Federal government, Water resources development, Project benefits, \*Wate Act, \*Expenditures, \*Legislation. Identifiers: Water Pollution Control Act. \*Water Quality

The article examines progress resulting from federal concern with water pollution, concentrating on the area of increased expenditures for pollution control on the federal and state levels. Although the history of federal pollution laws dates back to 1899, the Federal Water Pollution Control Act, passed in 1956, was the first comprehensive water pollution control law. This basic statute was supplemented by subsequent amendments and the Water Quality Act of 1965. This legislation has resulted in substantial progress-federal grants increased spending for waste treatment facilities 62 percent over that of the years immediately preceeding the federal-aid program. However, a backlog of waste treatment needs has climbed to a presently estimated \$3 billion. Minor legislation affecting water pollution, and the results of legislation on research on sewage treatment processes, are examined. Opinions of several persons prominent in stream pollution abatement are given. W68-00137

# THE USE OF ALGAE IN REMOVING NUTRIENTS FROM DOMESTIC SEWAGE,

Washington Univ., Seattle.

R. H. Bogan. Trans 1960 Sem on Algae and Metro Wastes, Robt A Taft Sanitary Engg Center, Cincinnati, Ohio, Tech Rept W61-3, pp 140-147, 1961. 8 p.

Descriptors: \*Eutrophication, \*Algae, Nutrients, Domestic wastes, \*Sewage treatment, Sewage, Biological treatment, Solid wastes, Microbiology, Activated sludge, Rates, Chlorella, Hydrogen ion concentration, Plant tissues, Scenedesmus, Limnology, Water properties, Water temperature, Alkalinity, \*Photosynthesis, Light penetration, Phosphorus, Lagoons,

Identifiers: Stigleoclonius, Insoluble wastes, Cul-

The soluble organic phosphorus in sewage may be converted by biological or chemical means into recoverable insoluble matter. The latter means has received more attention to date. The rate of removal by biological means is a function of celltissue synthesis which varies markedly with the type of organism. The mixed microbial cultures provided by the activated sludge process appear to be the most rapid mechanism. Chlorella,

Scenedesmus, and Stigleoclonius were grown in raw and treated sewage for the experiments, and the author studied their role in adjusting pH. Temperature, cell-tissue concentration, composition of culture media, and alkalinity influence the rate of photosynthetic pH adjustment. With adequate light, the minimum value being 100-200 f c, rapid extraction of phosphorus by photosynthetic biological activity is possible. A high-rate process was developed in the laboratory by which soluble phosphorus reductions of 90 percent or more were achieved in contact times of as little as 6-12 hours. Transferring the pilot-plant study to lagoonal waters 3-4 ft deep created lighting problems--sunlight could not penetrate deeply enough through the algal growth to cause an adequate photosynthetic response.
W68-00248

# PHOSPHORUS REMOVAL BY HIGH-DENSITY, SOLIDS-CONTACT TERTIARY TREATMENT, FWPCA, Washington, DC.

C. F. Garland.

Workshop on Phosphorus Removal Technology, Fed Wat Poll Control Adm, Chicago, Ill. pp 1-9, Jun 1968. 10 p, 6 fig, 5 ref.

\*Eutrophication, \*Sewage treatment, Lime, Flocculation, Solid wastes, Water costs, \*Pilot plant, Hydrogen ion concentration, Alkalinity, Biological treatment, Bibliographies, Benefits, Chemical properties, Cost analysis, Biochemical oxygen demand, \*Separation techniques.

The DENSATOR unit was developed (Fuller Co of Tucson, Ariz) to supplement physical-chemical processes of sewage separation. Strong dosages of lime, iron, alum, or combinations of them, are known to be effective in removing phosphorus; lime is the most effective of these additives. The unit provides a high-density, solids-contact treat-ment in 3 phases: (1) vigorous mixing of waste-water, lime, and a controlled volume of recircu-lated dense solids; (2) flocculation; and (3) solids separation, these being recirculated to (1). Tests of 10 pilot plants indicate that the addition of lime is increasingly effective in phosphorus removal as pH increases, but that the excessive pH of lime-treated effluents may require recarbonation before discharge. The unit permits split treatment and improved automatic controls for lime as adjusted to the ratio of alkalinity and calcium hardness of the influent wastewater. Filtration further reduces phosphorus content as well as BOD and suspended solids. This unit combined with the biological removal of soluble organics is effective. The operating cost of the 2-stage unit is somewhat higher, but the initial cost is lower, than the usual 1stage system. The high-quality water produced by this unit now costs about 40 cents/1,000 gal. W68-00254

## 5E. Ultimate Disposal of Wastes

# THE PHANTOM OF FEDERAL LIABILITY FOR POLLUTION ABATEMENT IN CONDEMNATION ACTIONS,

Mercer Univ., Macon, Georgia.

W. Reeves, Lewis, Sr. Mercer L Rev, Vol 17, No 2, pp 364-380, 1966. 17

Descriptors: \*Condemnation, Eminent domain, Water pollution, Legal aspects, \*Compensation, Judicial decisions, Project planning, Water alloca-Judicial decisions, Project planning, 8 act attaction (Policy), Riparian rights, Treatment facilities, Federal jurisdiction, Navigable waters, Nonnavigable waters, Flow, Natural flow, \*Pollution abatement, Water rights, Federal government.

Courts have held that the United States has the right to full use and flow of navigable waters and their nonnavigable tributaries to the exclusion of any other party, and should not be liable for changes in their flow. When a riparian owner has utilized a stream as a disposal for wastes, and subsequently has the natural flow of the stream abated by a federal project, thus preventing the wastes from being carried away, he is forced to use other methods of disposal. This is not a taking of his sewage system and should not result in the constitutional limitations upon payment of just compensation (usually fair market value of the land only) being overlooked. All uses of any location, whether on a navigable stream or not, are not guaranteed as property rights. Dumping of untreated sewage into tributaries of navigable waters causes pollution of the waters, which is an unlawful use of the waters, and does not constitute the basis of a claim for the taking of the landowner's alleged treatment system.

# 5F. Water Treatment and **Quality Alteration**

REPLENISHING THE AQUIFER TREATED SEWAGE EFFLUENT, WITH Ground Water Age, Vol 2, No 8, pp 30-35, Apr 1968. 6 p, 8 illus.

Descriptors: \*Artificial recharge, \*Injection wells, \*Groundwater, New York, \*Sewage effluents, Tertiary treatment, Filters, Specific capacity, Well screens, \*Recharge wells, \*Saline water intrusion, Well casings, Stainless steel, Potable water, Air en-Well casings, Stainless steel, Potable water, Air entrainment, Gases, Water reuse, Barriers, Water management (Applied), Water quality control. Identifiers: Degasifyers, Eh of water, pH of water, fiberglass casings, Salt water barrier, Air clogging, Water level monitoring.

Treated sewage from a recently completed tertiarytreatment plant is being used experimentally at Bay Park, N.Y., to recharge aquifers artifically. The purpose is to see if a barrier can be created to retard the intrusion of salt water into the heavily pumped aquifers. After treatment the effluent which meets potable-water standards is stored in a 50,000 gal storage tank where the pH and Eh of the water is adjusted chemically. Then it moves through a vacuum degasifier to remove air and other gases before it is pumped into the injection well. The well is a 36-in. hole, 508 ft deep, with a 15-ft thick cement plug at the bottom. It contains 62 ft of 16-in. stainless steel screen attached to 420 ft of 18-in. fiberglass casing. In the annular space the well has 2 3-in, tremie pipes for adding filterpack material, a 4-in. water injection pipe entering the casing 192 ft below the surface, and a 5-in. observation well. At a pumping rate of 1,000 gpm, the specific capacity of the well is 35 gpm/ft. Injection tests are at 400 gpm (576,000 gpd). If the project is feasible, similar wells will be constructed along 15 mi of ocean front and ultimately 27 mgd of treated sewage will be injected.
W68-00029

## FILTRATION THROUGH A TRIMEDIA FILTER

Camp, Dresser and McKee, Consulting Engineers, Boston.

Alan E. Rimer. ASCE Proc, J Sanit Eng Div, Vol 94, No. SA3, Pap 6014, pp 521-540, June 1968. 20 p, 12 fig, 11 rcf, 1

Descriptors: \*Filtration, \*Water purification, \*Testing, Filters, Equipment, Particle size, Sands, Comparative productivity, Analytical techniques, Design, Head loss, Porosity, Specific gravity, Hydrolysis, Flocculation, Separation techniques, Treatment.

Identifiers: \*Trimedia filters, \*Experimental results, \*Garnet, Iron floc, Backwashing characteristics, Sewage treatment applications.

Historical review of existing filter theory indicates the advantages of utilizing filter depth in a coarseto-fine media; use of multilayer filters is encouraged. Garnet of equivalent grain size possesses qualities of efficiency equal to that of sand. Filters with 3 layers composed of different size gradations

of anthracite, sand, and garnet are tested and compared with a conventional sand filter. The first test series was on filters comprised of 8-in layers of 1.19-mm anthracite, 0.590-mm sand, and 0.420mm garnet. A second test series is made on filters of 8-in layers of 1.00-mm anthracite, 0.707-mm sand, and 0.590-mm garnet. The conventional sand filter with effective grain size of 0.460-mm and a uniformity coefficient of 1.44 is used for comparison. Trimedia filters permit a head loss reduction of almost 50%, with no reduction in filtrate quality. Trimedia filters remain intact after repeated backwashing, but require more wash water and higher wash rates to clean than conventional filters. W68-00031

# THE ROLE OF DIATOMITE FILTERS IN COLOR REMOVAL-- DEVELOPMENT RE-PORT, Johns-Manville Research and Engineering Center,

Manville, NJ G. R. Bell. J New England Water Works Ass, Vol 82, No 1, pp 5-14, Mar 1968. 10 p, 7 fig.

Descriptors: \*Turbidity, \*Color, \*Water treatment, Engineering, Water quality, \*Diatomaceous earth, Water quality control, Technology, Water resources. Water purification, Treatment facilities, \*Research and development, New England, \*Fil-

Identifiers: \*Diatomite filters, Water-treatment methods, \*Filtering mediums, \*Color removal, APHA units, Turbidity removal, Filtered water.

The results of a 2-yr study of the use of diatomite filters in color-removal experiments are reported. The diatomite filters were used to prepare water for color removal with resinous adsorbents. The filters prevented the fouling of the adsorbents. Filtration alone reduced the color of Merrimack River by 10 to 20 APHA units and the color of Babson Reservoir water by 25 to 30 units. It is concluded that the filters play a useful role in color removal by providing a clean, non-fouling feed to the resin adsorbent units; they also reduce the color levels appreciably. Included are a schematic arrangement of filtered water system, and photomicrographs of filter aids and filter sand. W68-00055

# FLUORIDATION: THE COURTS AND THE OP-

Wayne State University Law School, Detroit. Robert Clark, and Michael M. Sophy. Wayne L Rev, Vol 13, No 2, pp 338-375, 1967. 38 p, 185 ref.

Descriptors: \*Fluoridation, Public health, Water purification, Human pathology, Judicial decisions, Legal aspects, Local governments, Legislation.

Although the scope and quantity of scientific evidence and the stature of the active proponents are impressive, fluoridation has not fared well when the choice is left to the people at the polls. Proponents of fluoridation include government agencies and respectable men of science, while op-ponents range from accredited scientists to uninformed laymen. If fluoridation has not done well at the polls it has done quite well when challenged in the courts. Courts are impressed by the quality and quanitity of evidence for both sides, and because conclusions of expert witnesses go in both directions, they generally feel that acceptance or rejection of one position is a matter of policy for legislative decision, not judicial determination. The principal arguments employed by opponents are lack of municipal authority, abuse of municipal authority, and violation of religious freedom. It is concluded that the referendum is a questionable means of deciding the issue, and that public ac-ceptance of fluoridation depends on more and better information, broad educational programs, and decreasing use of the referendum as a means of decision. W68-00123

# 5G. Water Quality Control

# LOW-FLOW CRITERIA FOR STREAM STAN-

US Army Corps of Engineers and Water Resources Research Center, Virginia Polytechnical Inst.,

Blacksburg William C. Ray, and William R. Walker. ASCE Proc. J Sanit Eng Div, Vol 94, No SA3, Pap 6005, pp 507-520, Jun 1968. 14 p, 4 fig, 4 tab, 10 ref, I append.

Descriptors: \*Waste assimilative capacity, \*Standards, \*Water Quality Act, Waste disposal, Water pollution, Low flow, Quality control, Streamflow, Virginia, Water resources, Flow characteristics, Hydrology, Frequency analysis, River basins, Droughts, Channels, Gaging stations.

Identifiers: \*Flow duration, \*Low-flow criteria, Drainage areas, Frequency curves, Environmental factors, Hydrologic parameters.

Virginia's 7-day, 10-yr low flow criterion for determining the capacity of a stream for waste assimila-tion is evaluated in 5 phases. These are: (1) selection of the gaging stations and the period of record to be evaluated; (2) obtaining low-flow summaries and daily discharge data; (3) preparation of frequency curves; (4) preparation of duration curves by a digital computer from the daily discharge data; and (5) evaluation of the 7-day, 10yr standard based on percent of time that the resulting design flow was equaled or exceeded during the period studied. Thirty yr of continuous daily discharge data were studied from 30 gaging stations located in 6 drainage basins. Analysis shows that the 7-day, 10-yr standard is uniform when applied to the Virginia areas. The standard provides a design that is, in all but one case, equal to or greater than 99 percent of daily flows. Therefore, no advantages are apparent in changing from the present 7-day, 10-yr minimum streamflow standard. This standard fulfills the low-flow criterion in the quality criteria needs of the 1965 Federal Water Quality Act. W68-00015

#### MEASUREMENT OF STREAM TRACER

REAERATION, (PART) 2-FIELD STUDIES, Georgia Inst. of Technology, Et Al E. C. Tsivoglou, J. B. Cohen, and S. D. Shearer. J Water Pollut Contr Board, Vol 40, No 2, Pt 1, pp 285-305, Feb 1968. 21 p, 3 fig, 6 tab, 10 ref.

Descriptors: \*Tracers, \*Streamflow, \*Water quali-Descriptors: \*Iracers, \*Streamflow, \*Water quality, \*Hydraulics, \*Flow rates, Tritium, Surface waters, Oxygen, Virginia, \*Reaeration, Streams, Radiation, Fluorescence, \*Dispersion, \*Methodology, Technology, Dye releases, Sanitary engineering, Movement, Mixing, Sampling, Monitoring, Mathematical models.

Identifiers: Krypton-85, \*Time of travel, \*Water movement, Jackson River, Fluorometer, Flu Fluorescent dye, Liquid scintillation counter.

3 tracers--rhodamine-WT, tritium, and krypton-85-were used simultaneously in field studies of reaeration in Jackson River between Covington and Clifton Forge, Va. The tracers were introduced as a homogeneous mixture to provide accurate data on the measurement of gas transfer and reaeration capacity of the stream. The dye gave data on time of travel and longitudinal dispersion: tritium, on total dispersion; and krypton, on total dispersion and gas transfer. The river was divided into subreaches of about 1.2 mi length for dye monitoring and sampling. River water was obtained by using a submersible pump connected to a continuous flow recording fluorometer on the bank. Part of the flow was diverted to sample bottles and sent to the laboratory for liquid-scintillation-counter mea-surements of tritium and krypton-85 and additional fluorometer measurements of dye. By measuring the relative concentrations of the indicator and tracer, the reaeration rate coefficient (k sub 2) can be determined. Overlap of subreach studies verified the reproducibility of the results which were within the general range of values from previ-

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ous studies. The study demonstrated the accuracy of the method and suggested that it might have additional applications. W68-00054

# RECONNAISSANCE OF THE CHEMICAL QUALITY OF SURFACE WATERS OF THE COLORADO RIVER BASIN, TEXAS,

**US** Geological Survey Donald K. Leifeste, and Myra W. Lansford. Tex Water Develop Board Rep 71, 78 p, Mar 1968. 13 fig, 6 tab, 26 ref

Descriptors: Runoff, Geology, Streamflow, Water pollution, \*saline water, \*Water quality, \*Surface waters, \*Chemical analysis, \*Chlorides, Dissolved solids, \*Hardness (Water), Areal, Mineral water, Texas, Oil fields, Hydrologic data, Irrigation water, Industrial water, Reservoirs, Brines, Brine disposal, Water sources, Water utilization.

Identifiers: \*Oil-field brines, \*Chemical analyses (Water), Mineral quality, Sampling sites, Saline-

The natural runoff from most of the 40,000 sq mi Colorado River basin is of good chemical quality and suitable for most uses. Mineral quality of the water is related to geology, rainfall, and streamflow except below Lake J. B. Thomas where inflow from oil-field brines impair the quality. Most of the tributary inflows have less than 250 ppm dissolved solids, but water in the main stem downstream from the area of saline inflow is generally above 250 ppm. The water ranges from moderately hard to very hard, and chloride concentrations range from less than 50 ppm to several thousand ppm. Chloride is highest in the upper reaches where brines reach the streams. Major water-supply reservoirs all have water of acceptable quality for most uses. The quality of water that will be stored in Robert Lee Reservoir, now under construction, will depend on the success of upstream control of saline water. Small-scale maps show the range in precipitation and runoff; locations of reservoirs, oil fields, gaging stations, and chemical-quality sampling sites; and geology. Important tables give the source, significance, and industrial tolerances for various mineral constituents; an index to surfacewater records; summary of chemical quality analyses at daily stations; and chemical analyses of water from other stations. W68-00057

## WATER AND AIR POLLUTION,

Florida League of Municipalities, Jacksonville. Ben H. Griffin, Jr.

Fla Municipal Record, Vol 41, No 10, p 7, Feb 1968, 4 p.

Descriptors: \*Florida, \*Legislation, \*Water pollution, Air pollution, Public health, Cities, \*Administrative agencies, Long-term planning, Administration, State governments, Inter-agency cooperation, \*Political aspects, Water zoning. Identifiers: Conflicting interests.

The Florida legislature recently passed a comprehensive statewide pollution control act giving the newly created Pollution Control Commission full authority over air, water, and solid waste disposal. This represents a move from primarily regional to statewide control of pollution. Prior to this act pollution authority on the state level was vested in the State Board of Health; but the many responsibilities of the Board of Health plus its medical orientation left too little time for pollution control. The article points out the highlights of the legislative battle for an antipollution bill and the conflicting interests which the final act represents. The administrative responsibilities and powers of the Pollution Control Commission are also discussed. W68-00103

#### THE LEGISLATIVE APPROACH TO AIR AND WATER QUALITY,

American Bar Association Section of Natural Resources Law, Chicago. Max N. Edwards.

Natural Resources Lawyer, Vol 1, No 1, pp 58-69, Jan 1968. 11 p.

Descriptors: Planning, \*Water pollution, Water quality, \*Legislation, \*Water Quality Act, Water pollution control, Water policy, \*Pollution abatement, Public health, Federal project policy, Administrative agencies, Water law, Water pollution treatment, Costs.

Identifiers: \*Water Pollution Control Act, \*Clean Water Restoration Act.

The Federal Water Pollution Control Act is the basic authority for the Department of the Interior in the field of prevention, control, and abatement of water pollution. This law continues the basic responsibility for controlling pollution in the states coupled with provisions for research, municipal waste disposal, and financing. This Act was amended in 1961 by the Water Quality Act and by the Clean Water Restoration Act of 1966. The Water Quality Act is unique in establishing quality standards for interstate waters to be prepared first by the states. Upon failure to establish standards or upon rejection by the federal government of the proposed standards, the Secretary of the Interior is authorized to impose standards. The Clean Water Restoration Act is designed to promote comprehensive river basin planning and is coupled with more liberalized funding provision for previous programs. Federal statutes provide two methods for enforcement of their provisions. The first provides for lengthy administrative procedures, which, if successful, may be followed by court action. The second provides for abatement actions to be brought by federal attorneys after notice if discharge causes water to fall below water quality standards

# WATER POLLUTION CONTROL IN NEW

YORK, Union Univ. Albany Law School, New York

W68-00105

Andrew Halloran.
Albany L Rev, Vol 31, No 1, pp 50-61, Jan 1967. 12 p, 70 ref.

Descriptors: \*New York, Riparian rights, Reasonable use, Water pollution, \*Water pollution control, Legislation, Competing uses, Judicial decisions, Pollution abatement, Cities, Treatment facilities.

The article's purpose was to trace history and development of water pollution control, with emphasis on recent statutory programs and enforcement problems in New York. The early development of reparian rights are discussed, and it is shown how the law of reparian rights and the reasonable use doctrine are applied to water pollution problems in New York. The amount of pollution damage necessary for issuance of an injunction is also discussed. An analysis of recent legislative enactments is made, and recent court decisions are presented in which application of pollution control laws to cities are at issue. The article concludes that the doctrine of reparian rights is of little value in controlling pollution, because riparian owners are not sufficiently motivated to exercise their rights, a multitude of lawsuits would be necessary to lessen pollution in most streams, and under the reasonable use doctrine a court may not always side with the lower riparian. Until recently, statutory programs have also been ineffective; but it is felt that the latest legislation may bring some progress in pollution control if enforcement efforts are increased W68-00110

# NOR ANY DROP TO DRINK: PUBLIC REGULATION OF WATER QUALITY PART III: THE FEDERAL EFFORT,

Iowa Univ., Iowa City. N. William Hines.

Iowa L Rev, Vol 52, No 5, pp 799-862, Apr 1967. 64 p, 308 ref.

Descriptors: \*Water Quality Act, Water pollution, \*Pollution abatement, Public health, Standards, Legislation, Federal government, Local governments, Political aspects, Political constraints, Federal jurisdiction, State jurisdiction, Water quality, Water purification.

The central problem of substantial federal involvement in water quality control is accomplishing national objectives of restoring water quality while maintaining appropriate respect for local institutions. Federal reluctance to lead war on pollution is probably due to the judgment, increasingly being questioned, that local control is the most efficient means of handling the problem. Lack of vigorous enforcement and inadequate local laws can be and are being remedied at the local level. However, many of the other aspects of pollution control can only be handled realistically at the federal level. The history of pollution control legislation shows continued resistance to increased federal involvement, based on the belief in primacy of state rights in the field. Current federal programs, including the Water Quality Act and its proposed and enacted amendments, provide for financial assistance in areas of research, training, demonstrations, and programs, as well as enforcement. Recent federal involvement has increased the effectiveness of local programs by making available additional funds, manpower, and technology. The concept of local control is being redefined and there is a growing conviction that local efforts should be organized on the basis of hydrological contours of waters, not political boundaries. W68-00113

# EFFLUENT CHARGES: A METHOD OF ENFORCING STREAM STANDARDS,

Maine Univ., Portland. Orlando E. Delogu.

Me L Rev, Vol 19, No 1, pp 29-47, 1967. 19 p, 1 tab, 58 ref.

Descriptors: Water allocation (Policy), Water pollution, Pollution abatement, Treatment facilities, \*Water pollution treatment, Waste disposal, Waste treatment, \*Cost allocation, Water quality. Identifiers: Effluent charges.

Water quality and not quantity is our most pressing resource problem. Federal and state governments are becoming increasingly aware of their responsibilities in pollution control and abatement. The Maine Legislature has created potentially effective pollution control machinery, but this has not been fully implemented, causing continued deterioration of the state's waters. The financial and political commitment necessary to attain water quality standards has been so large that states have been unwilling or unable to meet it. A modified concept of effluent charges would shift the cost of the present method of waste disposal (dumping wastes into the state's waters) from the state and downstream water users to the economic unit actually creating and disposing of the waste. The present method of waste disposal allows producers of waste products to shift part of their production costs to the state and downstream users, who must treat the water or forego its use. Using effluent charges, the total amount collected by charges would be equal to the cost of building and maintaining treatment facilities to keep water quality at standards established for the water. The charge to each economic unit would be proportional to its pro rata share of pollution. Several benefits are listed. W68-00115

# FORTY YEARS OF WATER POLLUTION CONTROL IN WISCONSIN: A CASE STUDY, Wisconsin Law School, Madison.

Donald M. Carmichael. Wis L Rev, Vol 1967, No 2, pp 350-419, Spring, 1967. 70 p, 1 append, 237 ref.

# WATER QUALITY MANAGEMENT AND PROTECTION—Field 05

## Water Quality Control—Group 5G

Descriptors: \*Watersheds (Basins), \*Wisconsin, Industrial wastes, Minicipal wastes, \*Administration, Administrative agencies, Judicial decisions, \*Adjudication procedure, Administrative decisions, Water law, Legislation, Water policy, Water resources, \*Pollution abatement, Remedies, \*Water pollution control, Water quality control.

Wisconsin's water pollution control program was administered for the last forty years by the State Board of Health and the state's Committee on Water Pollution. The functions of these two agencies were transfered in 1966 to the Wisconsin Department of Resource Development. The article describes in depth the procedures, problems, and achievements of the board and the committee during their years of work in order to guide future practice in the new department. The development of the Wisconsin regulatory process is first examined. Drainage basins are the basic organizational unit of the pollution control effort. The collection of data by the committee, its hearing procedure, preparation of orders, order rehearings and modifications, and agency and judicial review are discussed in depth. Problems dealing with private rights and the enforcement of agency orders, weak points in the Wisconsin system, are brought out. An overview of the problems experienced and the progress obtained under the Wisconsin experience is presented. Overall conclusions are then reached, finding that, on the whole, the activities of the committee and the board merit approval. The article ends, as it begins, with a discussion of finances. W68-00122

POLLUTION SOLUTION - A TOWNSHIP SEWERAGE SYSTEM,

Illinois State Bar Assoc, Springfield

Ronald C. Mattaz. 111 B J, Vol 52, No 10, pp 864-869, June 1964. 6 p, 28 ref, disc.

Descriptors: Illinois, \*Sewerage, \*Water pollution control, Government finance, Construction costs.

The author contends that township sewerage systems are the most practical method of pollution control in Illinois. Such systems can be financed by bond issues, federal funds for up to 30 percent of construction costs, and connection fees to the sewer users for the privilege of connecting to the system. The only legal prerequisite is the adoption by the Board of Town Auditors of an ordinance describing the project and the proposed bond issue Additional ordinances should be passed to regulate materials and methods used in the actual connection and to provide for township inspection. Connection to the system may be encouraged by discounting connection fees in the first years of operation. Easement problems may be largely overcome by provisions in the sewer user contracts granting blanket easements to the township. Additional easements must be obtained by individual negotiation. After all easements are obtained ordinances should be passed making connection mandatory and defining as nuisances any structures not connected. Such ordinances seem to be enforceable under existing cases, but the author recommends that the state legislature expressly grant this power. W68-00142

WATER QUALITY CONTROL IN GEORGIA,

Mercer University, Macon, Ga. Thomas W. Malone.

Mercer L Rev, Vol 16, No 2, pp 469-477, Spring 1965. 9 p, 1 fig.

Descriptors: \*Water quality control, \*Georgia, Legislation, \*Water pollution, Pollution abate-

This article reviews water quality control in Georgia by describing the earlier legislative acts and the most recent legislation, and outlines the procedures to be followed by the Board created under the 1964 act. The earlier acts did not contain a comprehensive definition of pollution and lacked effective means of enforcement. The 1964 act redefines pollution more comprehensively and gives the Board more extensive powers. This new act would be strengthened by the addition of a proposed amendment which would authorize the Board to adopt rules and regulations concerning disposal of sewage by marine toilets, remove the requirement of a mandatory hearing prior to the rendition of all orders of the Board, provide procedures for the conduct of hearings on orders and permits, and repeal conflicting laws. The procedures to be followed when pollution is discovered are outlined, and a flow chart puts the procedures to be followed in diagram form. W68-00150

LEGAL ASPECTS OF WATER POLLUTION CONTROL,

Water Pollution Control Federation, Washington,

Mitchell Wendell.

Water Pollution Control Federation Journal, Vol 39, pp 1945-1950, Dec 1967. 7 p, 1 ref.

Descriptors: Legal aspects, Legislation, \*Federal Government, Public health, \*Water pollution, Pollution abatement, \*Water pollution control, Political aspects, State government, \*Water Quality Act, Water quality control. Identifiers: \*Water Pollution Control Act 1965.

Traditionally pollution control has been predicated on the constitutional power of the states to safeguard public health, with very little action on the federal level. The Federal Water Pollution Control Act of 1965 declared that pollution in one state which endangers health in another state gives rise to a Federal constitutional interest, thus giving the Federal Government significant authority over water control. Prior to this act water quality standards were made almost exclusively by the states. Under this act standards are submitted by the states to the Secretary of the Interior. If the state produced standards are not approved, the Secretary must produce a set of acceptable standards. Standards produced according to the act are both state and federal substantive law, enforceable by either government. The Federal Government now directs state pollution control as well as dealing directly with polluters. The less money a polluter must expend to control pollution, the greater the probability that he will comply with the regulations, and the easier it is to enforce the regulations if he does not. Government provides financial aid to pollution control in the form of pollution control grants to municipalities, and tax incentives to private industry. W68-00153

#### FOCUS ON CLEAN WATER.

State Government Administration, Dcs Moines.

State Government Administration, Vol 3, No 1, pp 4-7. Jan 1968. 6 p.

Descriptors: Administration, \*Administrative agencies, \*Legislation, Inter-agency cooperation, Federal government, \*State governments, \*Water pollution control, Water quality control, Planning, Water Quality Act.

The article reports the results of a survey of state action to prevent and control water pollution. Measures taken in many states are the result of the Federal Water Quality Act of 1965. An overview of state control agencies and their operation, pollution control legislation, inter-agency cooperation, control problems and future programs is presented. W68-00154

STATE VS FEDERAL: PRIORITY IN POLLU-

TION CONTROL, State Government Administration, Des Moines. A. H. Paessler.

State Government Administration, Vol 3, No 1, pp 10-11, Jan 1968. 2 p.

Descriptors: \*Water Quality Act, Administration, \*Administrative agencies, State governments, Federal government, \*Water pollution control, Water quality control, Planning.

The thesis of the article, consisting of excerpts of a speech delivered by the author, is that the federal government is now dictating general policy and procedure in the field of water pollution control. Aggressive state action in the area is called for in order to prevent federal displacement of state activities. The principal source of federal authority, the Federal Water Quality Act of 1965, implemented by the Federal Water Pollution Control Administration, is examined as it relates to the states. Water quality standards and federal enforcement of these standards is given particular attention. W68-00159

WATER POLLUTION CONTROL--GEARING PERFORMANCE TO PROMISE.

American Society of Civil Engineers, Concord,

NH.

Edward J. Cleary. Civil Engineering, Vol 38, No 1, pp 62-64, Jan 1968. 3 p, 1 photo.

Descriptors: Legislation, Water pollution, Pollution abatement, Water treatment, Administrative agencies, \*Regulation, Government supports, Waste water disposal, \*Water quality, Waste water, \*Waste water treatment, Waste water (Pollution), \*Treatment facilities, Grants.

Performance in curbing water pollution is not meeting promises. State action in appropriating sufficient funds and in devising and supporting arrangements for the resolution of interstate pollution problems has been deficient. Federal strategy is uncertain. Each state was required to submit, by June 30, 1967, quality standards for interstate waterways. If these standards do not incorporate secondary treatment for every waste water discharge, they will be unacceptable. This request is difficult to sustain on scientific, engineering, or economic grounds. Federal grants to aid in construction of water treatment facilities, while large, are inadequate to bear the full burden and tend to stifle local initiative in constructing new unsubsidized water treatment facilities. Recent federal legislation was intended to supplement but not supercede state pollution control authority. Regulation has been based primarily on prohibitions, rather than management of water. Attention has been focused on existing federal and state administrative machinery, rather than exploring new arrangements. New approaches to the quality control problem by Maryland, New York, Ohio, Pennsylvania, and California are noted. These new mechanisms should be studied. W68-00161

WATER QUALITY STANDARDS. Federal Register, Vol 33, No 133, pp 9877-9880, Jul 10, 1968. 3 p.

Descriptors: Federal government, Water Quality Act, Standards, \*Water pollution control, Legisla-

18 CFR 620 is revised so as to include the scope and purpose of section 10 (c) of the Federal Water Pollution Control Act, as amended, 33 U. S. C 466g (c), and the adoption, availability, and identification of state water quality standards as provided for in the Act. State water quality standards, consisting of water quality criteria and a plan for enforcement and implementation of the criteria, are the standards applicable to the interstate waters or portions thereof of each state for which adopted, if adopted by the state after notice and a public hearing, and if determined by the Secretary of the Interior to serve the purposes of

# Field 05-WATER QUALITY MANAGEMENT AND PROTECTION

## Group 5G-Water Quality Control

the Federal Water Pollution Control Act. These adopted standards are available for inspection at the Regional Offices and Headquarters of the Federal Water Pollution Control Administration. Water quality standards adopted by the states and accepted by the Secretary as of the date of this issue of the Federal Register as consistent with the Federal Water Pollution Control Act, except as otherwise indicated, are identified according to state. W68-00200

ANALYSIS OF FEDERAL WATER POLLUTION CONTROL LEGISLATION, 1948-1966,

American Water Works Association, New York Leonard B. Dworsky.

American Water Works Association Journal, Vol. 59, No 6, pp 651-668, June, 1967. 18 p, 14 ref.

Descriptors: \*Legislation, Water pollution, Planning, Administrative agencies, \*Federal government, \*Water pollution control, Water pollution treatment.

Identifiers: \*Water Pollution Control Admin.,
\*Clean Water Restoration Act, \*Water Pollution Control Act.

Since the Water Pollution Control Act of 1948 Congress has played a dynamic role in water pollution control. This article attempts to set in perspective general principles of water pollution control legislation for the period 1948-1966. Early legislation was limited to technical assistance, leaving the major burden on the states. The 1948 Act stated a new basic policy of active participation by the Federal government in the area of water pollution The Federal Water Pollution Control Administration was set up under the control of the Surgeon General. Federal grants to water pollution control programs were authorized. A 1956 ammendment established a system of 'conferences' of the Federal government with states on pollution problems as a means of initiating remedial action The Federal government took action to assure that its own facilities were not contributing to pollution. Studies of watercraft pollution and Federal aid to industry for pollution control were authorized. The Clean Waters Restoration Act of 1966 switched the Administration from the Department of Health, Education and Welfare to the Department of the Interior. Federal guidelines for establishment of water quality standards were sent to each state in 1966. W68-00208

FWPCA PROPOSES...A 20TH CENTURY PRO-GRAM, FOR WATER POLLUTION CONTROL, Reuben H Donnelly Corp, New York Richard P. Nalesnik

Water and Wastes Engineering, Vol 5, No 2, pp 59-62, Feb 1968. 4 p, 2 tab, 5 chart.

Descriptors: Water treatment, Water pollution, Costs, Legislation, \*Planning, Water supply, Waste water treatment, \*Water pollution treatment, Water pollution control, \*Sanitary engineering, Water requirements, Administrative agencies. Identifiers: \*Water Pollution Control Admin, \*Clean Water Restoration Act.

The Federal Water Pollution Control Administration received a mandate from Congress in the Clean Water Restoration Act of 1966, 'to assess the national requirements and related costs for treating municipal, industrial, and other effluents.' The United States has the technical power to manage the complex water pollution problems caused by increased urbanization and industrialization, if financing can be provided. The Water Pollution
Control Administration is now working to identify pollution problems and determine the cost of al-ternate solutions. The advantages and disad-vantages of automatic data processing and increased computer use are under study. Regional offices are focusing on the potential benefit of pollution control and abatement action programs under twenty major river basin managers. Federal assistance is being provided to state water quality control agencies, and in the monitoring of state water standards. Charts showing municipal, industrial, and agricultural water use, 1900-1980 are included. Tables showing sufficiency of future urban water supplies, and alternate means of meeting future demands are provided. A programmed approach to determining an industrial waste profile is given. W68-00214

INTERGOVERNMENTAL RELATIONS IN WATER QUALITY CONTROL,

Water Pollution Control Federation, Washington, DC

Mitchell Wendell.

Water Pollution Control Federation, Vol 39, No 2, pp 278-284, Feb 1967. 7 p.

Descriptors: Water Quality Act, Federal government, \*Water quality control, Water Resources Planning Act, Water pollution, Water quality, \*Standards, \*Administration, Planning, \*Coordination, Regulation, Water resources development.

Identifiers: \*Water Pollution Control Admin, \*Intergovernmental cooperation, \*Department of In-

Recent entry of the Federal government into the area of water quality control previously handled by state or local authorities has created a need for intergovernmental cooperation. The Water Quality Act of 1965 provides that the states shall submit water quality control standards to the Secretary of the Interior for his approval by June 30, 1967. If the standards so submitted are not approved, standards are set by the Secretary. State standards which do not provide for treatment of all wastes amenable to treatment and the maintenance of at least present purity levels will not be acceptable. It is suggested that a regional intergovernmental body, rather than a state or Federal agency, would be more appropriate means both of setting up and enforcing water quality standards. The Federal Water Control Administration has been switched from the Department of Health, Education, and Welfare to the Department of the Interior, and it will take time for state and local authorities to readjust. The Water Resources Planning Act provides for joint federal-state planning bodies for water management on a regional or river basin basis. W68-00218

#### STATES' WATER STANDARDS NEED RE-WORKING.

American Chemical Society, Washington, DC

Chemical and Engineering News, Vol 45, No 24, pp 38-40, June 5, 1968. 3 p, 1 fig, 3 photo.

Descriptors: \*Standards, Federal Government, \*Legislation, Water pollution control, Planning, \*Water Quality Control, \*Water Quality Act, Water pollution, Treatment facilities, Administration, Regulation.

The Water Quality Act of 1965 requires the states to submit water quality standards to the Federal Water Pollution Control Administration by June 30, 1967. Each state must specify how it plans to monitor and enforce these standards. All forty entries so far need reworking. None of the enforcement plans is acceptable. Few states have submitted a full set of standards all at once. Each river represents a single set. Coordinating one state's standards with up- or downstream states is a difficult task. The greatest problem area is surveil-lance and enforcement. The idea behind the standards is to enhance the quality of interstate water, or, if already clean, to maintain its cleanliness. Five committees have been set up to determine just what constitutes clean water for the purposes of agriculture, recreation, aquatic life, public water supply, and industrial water supply. Once this determination has been made, monitoring systems must be set up. The Federal Water Pollution Control Administration says it will be flexible in accepting state standards, due in part to incomplete knowledge of water pollution control needs. A study of pollution control needs on the Houston ship channel is noted. W68-00219

THE APPLICATION OF THE COMMERCE POWER TO ABATE .....POLLUTION,

George Washington Univ., Washington, DC.

Sidney Edelman. Geo Wah L Rev, Vol 33, No 5, pp 1067-1087, June 1965. 21 p, 122 ref.

Descriptors: Air pollution, Air pollution effects, \*Clean Air Act, \*Pollution abatement, Water polution, Public health, Legal aspects, Water pollution control, Water pollution effects, Federal government, Interstate, Water law, Judicial decisions, Legislation, \*Federal jurisdiction, Federal-state water rights conflicts.

Identifiers: \*Federal Water Pollution Control Act, Federal Constitution, Constitutional law

The constitutional issues involved in the application of federal government controls over air and water pollution are examined. The constitutional questions presented are not unique, but they require that the federal commerce power be analyzed on the basis of its application to new phenomena of modern society. Pressure for federal enforcement in this area arose from the interstate nature of pollution problems. The authority of Congress to deal with the problems depends on whether the pollution travels or is transported across state lines, or affects travel across state lines. With respect to water polution it is concluded that the Federal Water Pollution Control Act was intended to apply to all interstate waters, whether navigable or not, but only to intrastate waters which are navigable. The power of Congress to regulate navigable waters extends to the protection of these waters. Federal jurisdiction over interstate air pollution is complete under the Clean Air Act. Jurisdiction over intrastate pollution rests on the fact that pollution affects interstate commerce or obstructs the navigable air space. The same principles which underlie the authority of Congress to protect navigable waters are applicable to navigable airspace.
W68-00237

RIGHTS AND REMEDIES IN THE LAW OF STREAM POLLUTION.

Virginia Law Review Association, Charlottsville.

Va L Rev, Vol 35, No 6, pp 774-786, Oct 1949. 13 p, 72 ref.

Descriptors: \*Remedies, \*Water pollution, \*Water law, Legislation, Federal government, Interstate compacts, Water quality, State government, Water pollution control, Administrative agencies, Water

Identifiers: Common law, Injunction, Damages (Legal aspects).

An examination is made of remedies afforded by the common law, equity, state statues, interstate compacts, and Federal legislation to one damaged by stream pollution. At common law each riparian owner is entitled to reasonable use of water flowing through his land for domestic, agricultural and manufacturing purposes, and may bring an action for damages and injunction against an upstream polluter. State statutes have been passed to supplement common-law remedies. These statutes are of two general types-criminal and regulatory. State statutes have been more effective than common law remedies but suffer from lack of enforcement, inadequate financing, and lack of public support. Interstate pollution control compacts allow the states to act to control pollution. The Federal Water Pollution Control Act of 1948 declares interstate pollution to be a public nuisance, abatable by the United States. The article concludes that the remedies available today are sufficient to control pollution in most streams, but only if they are pursued. W68c00244

# 06. WATER RESOURCES **PLANNING**

# 6A. Techniques **OF Planning**

WATERPOWER RESOURCES.

U S Geological Survey Arthur Johnson. US Geol Surv Prof Pap 580, pp 48-51, 1968. 4 p, 1 fig, I tab.

Descriptors: \*Hydroelectric plants, \*Electricity, Streamflow, Dams, Electric power demand, Reservoirs, Water utilization, Rainfall, Economic feasibility, Appalachian Mountain Region.

bility, Apparachian Mountain Region: Identifiers: \*Waterpower, \*Generating capacity, Megawatts, Streampower, Potential waterpower, Peak demands.

The objective is to summarize historical development of waterpower in Appalachia and point out undeveloped sites for future hydroelectric plants needed in the economic growth of the region. Developed and undeveloped waterpower sites of more than 50,000-kw capacity are shown on a small map keyed to a table which lists by States the site names, stream location, and capacity in kw. Other tables show the developed and undeveloped waterpower capacity and a summary of sites giving installed and proposed capacities in mw. Generating capacity totals 5,265 mw in 133 installed hydroelectric plants. Potential sites have been identified at 163 places that could be developed to add another 10,700 mw capacity. Economic development of Appalachia will require additional electrical apparatus of the property of the control of electrical energy; waterpower logically can and should be developed to complement streampower.

# PRESERVATION VALUES IN RIVER BASIN

PLANNING, New Mexico Univ. School of Law, Albuquerque

Roger Tippy. Natural Resources J, Vol 8, No 2, pp 259-278, Apr 1968. 20 p, 2 tab, 58 ref.

Descriptors: \*Preservation, Water utilization, \*Administrative agencies, \*Decision making, \*Federal project policy, Long-term planning, Water policy, Recreation demand, \*River basin development, Water resources development, \*Administrative decisions, \*Legislation, Political aspects, Social values, Water law, \*River basins, \*Optimum development plans.

Identifiers: \*Preservation values, Development

Comprehensive river basin planning is in part a matter of making reasoned choices between potential uses of a river when they conflict, and it should illuminate all values involved. The promise of comprehensive river basin planning is that one can look over the entire area and indicate how competing preservation and development values can be maximized. Two forms of conflict resolution are available: planners can either present decision-makers with alternatives or a compromise. The first form is the official federal doctrine; but experience shows that the second form is closer to actual practice. Descriptions of operations in the Army Corps of Engineers, the Federal Power Commission, and the Department of the Interior illustrate this statement. The article examines the practices and development decisions of these agencies. Preservation decisions made in the wild rivers studies and legislative proposals attempting to implement these decisions are discussed. The potential of com-prehensive river planning is demonstrated in the Missouri River project. Revision of fragmented Congressional committee responsibilities by creat-

ing Committees on Natural Resources in each branch is suggested as an alternative to creating a Department of Natural Resources in the executive branch

W68-00114

#### CREATIVE FEDERALISM: RECENT TRENDS IN REGIONAL WATER PLANNING AND DEVELOPMENT, RESOURCES

U of Colorado Law Review, Boulder,

Gary W. Hart.

U Colo L Rev, Vol 39, No 1, pp 29-47, Fall 1966 19 p. 55 ref.

Descriptors: \*River basins, \*River basin development, \*River basin commissions, Water resources, \*Legislation, Regional analysis, \*Water resources development. Administration, Administrative agencies, Inter-agency cooperation, Interstate commissions, Long term planning, \*Water Resources Planning Act, Water law, Legal aspects.

Creative federalism is a new governmental phenomenon for solving problems on a region-by region basis. Recent trends in water resources planning and development are illustrative of this phenomenon; and one of the most important steps in this trend is the Water Resources Planning Act of 1965. This act establishes a Cabinet-level Water Resources Council which, among other things, has the duty of studying the adequacy of water supplies in each water resources region. The act contemplates the establishment of regional commissions for river basin planning. The provisions of the act, their importance, and some of the act's weaknesses are discussed in detail. The Clean Waters Restoration Act of 1966 also contains relevant provisions for river basin planning, one of the most important being the power to give grants to agencies developing comprehensive water control and abatement plans for a river basin. Several deficiencies in the act are pointed out. Related regional legislation involving water resources planning and development is examined. Conclusions are then reached as to the changes these laws have brought about in the course of water resources development and problems that must be faced in the future. W68-00136

BENEFIT-COST ANALYSIS: ITS RELEVANCE TO PUBLIC INVESTMENT DECISIONS: COM-

MENT, Grinnell College, Grinnell, Iowa. Robert H. Haveman.

Quart Jour Econ, Vol LXXXI, No 4, pp 695-699, Nov, 1967. 5 p.

Descriptors: Welfare, Efficiencies, Investment, \*Cost-benefit theory, Cost analysis, \*Income anal-

Identifiers: Public expenditure, \*Income redistribu-

It has recently been argued that contemporary benefit-cost analysis is not very useful since the objectives of most public expenditures are primarily concerned with redistributing income rather than economic efficiency. This argument, although correct, did not distinguish between public investment undertaken to correct market failure and public investment designed to promote some aspect of welfare. The failure to analyze the latter through costeffectiveness rather than cost-benefit analysis is primarily responsible for the inadequacy of the policy proposed. The distributional impact of a public expenditure was equated with the disbursement pattern of project benefits and the other channels by which public expenditure redistributes income were neglected. Thus the possibility of finding the true redistribution impact was viewed with overoptimism. This argument also reinforced the unsubstantiated view that declines in efficiency in public water resource investment are justified, since in general they redistribute income in the 'right' direction. The three research efforts, with one partial exception, that dealt with the direction of the net redistributive impact of these programs did not support this hypothesis.

W68-00170

THE IMPACT OF THE OWEN FALLS HYDRO-ELECTRIC PROJECT ON THE ECONOMY OF UGANDA.

Durham Univ., Great Britain, London School of Economics

Walter Elkan, and Gail G. Wilson.

Jour Devel Studies, Vol 3, No 4, pp 387-404, July, 1967. 18 p, 6 tab.

Descriptors: \*Hydroelectric power, Rural areas, \*Electric power costs, \*Industrial production, Diversification.

Identifiers: Uganda, \*Owen Falls Dam, Economic development, Social overhead capital.

The hydro-electric project was intended to provide 'cheap and ample electricity' and this was expected to facilitate rapid industrialization. The demand for electricity did not rise as rapidly as expected and large amounts of it were sold to Kenya. Some industrial development did occur; 2 or 3 large industrial enterprises using about a quarter of total output might otherwise never have gone to Uganda. But there has been no industrial revolution, the percentage of GNP generated by manufacturing has remained at about 5%. Despite great efforts to sell electricity to African domestic consumers, their number is still under 25,000 and the number of units sold per consumer has fallen to less than half since Europeans and Asians have begun to leave the country. The small number of new industries attracted from abroad have certainly helped to diversify Uganda's exports and in the case of textiles well reduced her dependence on imports. Ultimately the project is bound to have been worthwhile if only because of the lack of viable alternative uses for the resources that went into its W68-00171

# PARETO OPTIMALITY AND THE LAW,

London School of Economics.

E. J. Mishan.

Oxford Econ Papers, Vol 19, No 3, pp 255-287, Nov, 1967. 33 p, 1 fig, 1 tab, 15 ref, 2 append, 3 matrix.

Descriptors: \*Welfare, Compensation marginal utility, \*Benefits, \*Constraints, Costs, Income, Distribution, Feasibility

Identifiers: Externalities, Pareto improvement, \*Laws, Conflict of interest.

In cases of conflicting interest, according to the law, deliberately or by default, places the burden of reaching optimal arrangements on one party or group rather that the other, both the characteristics of the optimal outcome and the costs of its attainment are altered. An optimal solution emerging from conflicts of interest is optimal only with respect to an implicit constraint requiring the area in question to be used in common by the groups having conflicting interests. If the possibility of separate facilities is introduced, new superior solutions become available. These propositions are demonstrated heuristically. The paper attacks the belief that an optimal solution in a partial setting is uniquely determined and it is further contended that there are several reasons for expecting the patterns of costs and outputs to differ substantially according as the law is or is not predominantly permissive. It is concluded that legislation recognising the citizen's right to amonity would be more equitable and promote a wider range of choices. W68-00174

LAW AND RESOURCES PROBLEMS.

American Bar Association, Chicago. Benjamin V. Dall. ABA J, Vol 53, pp 433-435, May 1967. 3 p, 7 ref.

Descriptors: Land use, Land resources, \*Future planning, Long-term planning, \*Resource allocation, Rural areas, Water allocation (Policy), Legal aspects, Water resources, Zoning, Public rights,

# Field 06—WATER RESOURCES PLANNING

# Group 6A—Techniques of Planning

Reparian rights, Social change, \*Social needs, \*Social values, Decision making. Identifiers: Community costs.

Laws and institutions must change to meet problems. One such problem concerns the use and abuse of our land and water resources. Lawyers do not concern themselves with planning for change. The question is: should the law, as the social force which implements values, play an active role in direction planning. There is a need for communication between disciplines. Laws of private property and the individualistic bias are the result of the belief that material productivity would lead to social good. This individualistic bias is the core of all of our land and water resource problems. E. G. riparian rights and the absence of land-use controls. Too much is lost between planning and implementation of resource-use policy because of intervening private rights. The status quo is favored over future planning. Thus there is no consensus in our social values concerning the allocation of land and water resources. An increased consciousness of role and a greater professional perception of our total environment are needed. W68-00193

SOME IMPORTANT RESEARCH PROBLEMS IN THE WATER RESOURCES FIELD,

New Mexico Univ., Albuquerque.

1965. 12 p.

Blair T. Bower. Natural Resources J, Vol 5, No 2, pp 286-297, Oct

\*Water resources development, Descriptors: Research and development, Project planning, Data collections, Coordination, Operations, Benefits, Water quality control.

There are a few particularly pressing areas of research need in order to improve water resource development and management decisions. The first problem area is that of handling uncertainty in water resources system planning, which stems from difficulties in estimating future changes and de-mands. This can be coped with by incorporating flexibility in water resources systems, by analysis of alternative patterns of demands over time, and by changing the end product-time focus of water resources planning. Secondly, studies of the relative accuracy and precision of data relating to water resources systems are needed. This would allow better allocation of available resources and more rational decisions as to the degree of refinement of the overall planning effort. Thirdly, private, federal, state, local, and regional operating decisions need to be integrated in order to improve efficiences of water resources systems. Fourth, operating procedures must be developed for individual water resources systems which produce optimal operation for all of the system's units. The fifth problem is the development of water quality improvement benefit functions related to various water quality parameters for various users. W68-00223

## 6B. Evaluation Process

SURFACE WATER RESOURCES PLANNING IN **HUDSON BASIN,** 

Tippetts-Abbett-McCarthy-Stratton, Consulting

Engineers, New York, New York State Conserva-tion Dept., Albany. Gerald T. McCarthy, and Nicholas L. Barbarossa. ASCE Proc, J Hydraul Div, Vol 94, No HY2, Pap 5841, pp 375-389, Mar 1968. 15 p, 3 fig, 3 tab.

Descriptors: \*Water management (Applied), \*Planning, \*Water supply, Reservoir construction, Design, Low flow augmentation, Groundwater, Water utilization, Streamflow, Desalination, Tidal waters, Saline water intrusion, Hudson River, New York, Water conveyance, River basin develop-ment, Hydraulics, Water demand, Water quality. Identifiers: \*Potential water supplies, \*Water necds, \*Potential reservoir sites, Organic pollu-tants, Estuarine effects, Isochlor.

Consultants studied water resources of the Hudson-Mohawk River Basin and Long Island, a 15,000 sq mi area with a population of 13,000,000 people. Primary objectives were to evaluate the quantity and general quality of the ground and surface water, to assess present utilization, and analyze and project the water needs to the year 2020. The entire area was screened for possible reservoir sites; suitable storage projects were located in the headwater areas. Techniques used to screen potential reservoir sites are described and believed to have wide application to water resource planning for large river basins. Alternative solutions are outlined for municipal water supplies for: (1) Upper Hudson River Basin; (2) Mohawk River Basin; (3) Lower Hudson River Basin; and (4) New York City, Westchester County, and Long Island. Special attention is given to water problems of New York City and vicinity. Tentative plans showing costs of a number of alternative solutions to problems are presented for future metropolitan water supply W68-00044

**SPECTRAL AUTOCORRELATION** AND ANALYSES IN HYDROLOGY,

Pittsburgh, Univ. Rafael G. Quimpo.

ASCE Proc, J Hydraul Div, Vol 94, No HY2, Pap 5837, pp 363-373, Mar 1968. 11 p, 4 fig, 23 ref, 2

Descriptors: \*Mathematical models, Flow, Rivers, \*Hydraulics, \*Data processing, \*Analytical techniques, Computers, Automation, Idaho, Model

techniques, Computers, Automation, Idano, Model studies, Cycles, Discharge (Water), Statistics, Streamflow, Hydrologic aspects.
Identifiers: \*Spectral analyses, \*Autocorrelation, Harmonics, Spectra, Correlograms, Boise River, Economic time series.

An analysis is made of 40 yr of daily flow records of the Boise River near Twin Springs, Idaho, using autocorrelation and special techniques. The methods of analysis are compared relative to economy and extracted information. For statistical prediction, autocorrelation is shown to be more economical The discriminatory power of the spectral density function, which allows detection of noncommensurable harmonics, carried little weight for the time series studied. A reduction in calculations can be achieved by examining the behavior of the correlogram, only in the vicinity of suspected periods. In modeling, autoregressive techniques may be readily extended to the multivariate case. The intended use of results is also a factor in choice of methodology in data analysis. W68-00046

POLICY AND PLANNING FOR RECREATIONAL USE OF INLAND WATERS, Temple Univ., Philadelphia.

Robert I. Reis.

Temp L Q, Vol 40, No 2, pp 155-193, Winter 1967. 39 p, 82 ref.

Descriptors: Water utilization, Non-consumptive use, Competing uses, Planning, \*Recreation demand, Access routes, Recreation, Ownership of beds, \*Non-navigable waters, Navigable waters, Water demand, Civil law, Public rights, \*Water policy, Water resources development, Jurisdiction, Eminent domain, \*Riparian rights, Social values, Lakes

Identifiers: State ownership, \*Surface rights, \*Common law rule of bed ownership, Civil law rule of bed ownership.

Public demand for water recreation is limited by the finite number of inland waterbodies and private ownership. Two methods are available for placing private property rights and public needs in perspec tive. The first is judicial, involving manipulation of the navigability test to vest title to underlying land in the state so that it can regulate surface use. If a waterbody is labeled navigable, the state retains ownership of the bed and control over the surface. But if the waterbody is nonnavigable, the bed is the

subject of private ownership and use of the surface is the subject of private control, qualified in the great majority of cases by the right to any reasona-ble use of the surface by riparian owners. The judi-cial method, however, is unsatisfactory because it defeats expectations flowing from private ownership and fails to adequately serve the recreational needs of the public. The second and preferable method involves the legislative power of eminent domain. When used in connection with proper state planning this method is better suited to protect the institution of private property and to benefit the public need for recreational facilities. W68-00101

FEDERAL WATER RESOURCE DEVELOP-

MENT, Oregon Univ., Eugene. W. H. Stewart.

Oregon L Rev, Vol 45, No 4, pp 322-336, June 1966. 15 p, 1 fig, 1 tab, 30 ref.

Descriptors: River basins, Flooding, \*Water utilization, Flood control, \*Water control, Administration, Flood control, Water Control, Administra-tive agencies, Administrative decisions, Federal government, Federal project policy, Long-term planning, \*Oregon, River basin development, Water law, Water policy, \*Water resources development, \*Cost-benefit analysis, Legislation, Recreation.

The article discusses the development and current status of that aspect of the field of natural resources known as 'water resources development,' covering the general policies of the federal government in this area. Water resource development is defined in terms of a composite of the views of many people, involving the use, conservation, and control of water and related resources through multi-purpose development to give the maximum benefit to mankind. Several inherent needs of water resource development are listed. On the basis of this definition the history and present status of governmental interest in developing water resources is examined. Federal interest dates from 1920, the Reclamation Act of 1920, the river survey of the United States requested by Congress in 1925, and the 1936 Flood Control Act being milestones leading to the present interest. The cost-benefit formula for federal participation in the improvement of streams and watersheds remains unchanged from the 1936 act. Presently, federal interest centers on eight potential purposes of water resources development: flood control; irrigation; navigation; power; water supply; water quality control; fish and wildlife enhancement; and recreation. W68-00116

WATER AND THE NATIONAL WELFARE-PROGRAMS IN SEARCH OF A POLICY, Washington Univ., Seattle.

James A. Crutchfield.

Wash L Rev, Vol 42, pp 177-187, 1966-1967. 11 p, 1 ref, disc.

Descriptors: Economics, Cost-benefit ratio, Feasiblity studies, \*Resource allocation, Irrigation, Crop production, Water conservation, \*Administrative agencies, Planning, \*Comparative costs, Columbia River, Southwest, U. S., \*Governmental supports, Water policy.

This article is an adaptation of the author's statement before the Senate Interior and Insular Affairs Committee, advocating the creation of a national water commission. It is urged that regional water problems can be resolved only as a part of a consistent national program, since specific local problems are linked in a national pattern by over-lapping supply and demand interdependence. Present governmental water policies in some water-deficient areas, notably the Southwest, are committed to providing water at prices below cost. This encourages the raising of water-intensive crops in areas better suited to other use and the substitution of water, whenever possible, for other productive services in industry. The feasibility of deverting the

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Columbia River to the Southwestern States is seen as a function of a cost-benefit ratio. A plea is made for water management on an economically sound nation-wide basis, rather than divided among state, loacl and federal agencies which are subject to regional commitments. W68-00125

# GROUND WATER RIGHTS AND DEPLETION

New Mexico Univ. School of Law, Albuquerque. Sho Sato.

Natural Resources J, Vol 6, No 2, pp 237-247, Apr

1966. 11 p, 50 ref.

Descriptors: \*Taxes, Groundwater mining, Water table, Unit costs, Percolation, Overdraft, Groundwater recharge, Mineralogy, Appropriation.

The purpose of this article is to ascertain the precedential value of United States v. Shurbert 347 F. 2d 103 (5th Cir. 1965). The Court allowed a cost depletion deduction to the taxpayer for mixed ground water. The depletion computation was based on a comparison of land costs with and without groundwater rights. The policy behind the deduction is the depletion of an exhaustible supply of water, just as depletion of minerals. Fundamental to the taxpayer victory was the characterization of water as a natural deposit. The deduction was computed on the basis of reduction of the water table but this method was warranted by the facts of the case. This may be an inappropriate method if there are several wells in the same basin. The author presents two alternative methods of computation as well as alternative methods of determining unit cost when the water table decline is used. The effect of ownership of percolating groundwater is discussed. The effect of recharge and overdraft on the depletion deduction is also examined. The author discusses adjustments to basis and expense deductions under Internal Revenue Code sections 615 and 616. W68-00129

# CHAOS OR UNIFORMITY IN BOATING REGULATIONS, THE STATE AS TRUSTEE OF NAVIGABLE WATERS, Wisconsin Univ. Law School, Madison.

Richard W. Cutler. Wis L Rev, Vol 1965, No 2, pp 311-321, Spring 1965. 11 p, 47 ref.

Descriptors: Boats, Regulation, State government, Administrative agency, Jurisdiction, \*Ownership of beds, Political aspects, Public rights, \*Recreation, State jurisdiction, \*Boating, \*Boating regulation, \*Sector, Water child, Water and Administration of the public rights of the pu Safety, Water skiing, Water sports, Administration, Local governments, Navigable waters, \*Wisconsin. Identifiers: \*State Trust Doctrine.

Increased recreational use has increased the need for boating regulation. Before 1959 all Wisconsin boating regulation was local. In 1959 a state boating act was passed to provide uniformity of regulation while reserving some local flexibility. This act proved unsatisfactory in that it (1) left too much discretion to local regulations (2) ignored the trust doctrine. The Wisconsin constitution provides that the state holds title to the beds of navigable waters in trust for the public. This doctrine gives the public broad rights in the state's navigable waters. The state may not delegate to its agents (local governments) its duty to administer this trust. The 1959 act failed to achieve the judicial compromise between competing needs for uniformity and local variations to meet local problems. As a solution to the problem the article suggests adoption of a Michigan type of regulatory statute. Significant features of this statute are (1) creation of a State Boating Agency with sole power to regulate, (2) clear expression of state policy on boating regulation (3) provide uniform statewide rules (4) provides a method of establishing local rules by joint state and local action

# EXPLOITATION OF SUBMARINE MINERAL RESOURCES BEYOND THE CONTINENTAL

Texas International Law Forum, Austin. David S. Browning.

Texas Int'l L Forum, Vol 4, No 1, pp 1-27, Winter

Descriptors: \*Continental shelf, International waters, Law of the sea, Exploitation, \*International commissions, \*United Nations, Political aspects, International law, Legal aspects, \*Resource allocation, Deep water, \*Ownership of beds, \*Public rights

Identifiers: National flag theory.

The Continental Shelf Concept limiting national jurisdiction of the seabed is ambiguous. However, it is the most practical test available. Beyond the shelf the question of ownership is unresolved. Until some international arrangement is concluded regarding ownership rights and licensing procedures for mineral resources, investors may be reluctant to venture into deep ocean mining. Weather the sea bed admits of appropriation by any nation may depend on whether it deemed res nullius or res communis. However, these old concepts are incapable of providing the basis for a viable regime in this area. It is preferable to base the system upon contemporary economic, social, and political factors. To allocate the seabed on the basis of occupation may lead to land grabbing and international conflict. An international agency, vested with ownership of the seabed and authorized to lease it to nations and corporations is a desirable alternative. The existing international political climate, however, forcloses present implementation of such a regime. The best system, presently workable, is utilization of the exploitability test and occupation, leaving resolution of conflicts to negotiation, arbitration and adjudication, while attempting to formulate a satisfactory international regime. W68-00134

UNEMPLOYMENT, EXCESS CAPACITY, AND BENEFIT-COST INVESTMENT CRITERIA, Grinnell College, Grinnel, Iowa Resources for the Future, Washington, DC Robert Haveman, and John Krutilla.

Rev Econ and Stat, Vol XLIX, No 3, pp 382-392, Aug 1967. 11 p, 3 fig, 3 tab.

Descriptors: Real costs, Alternative costs, Water demand, \*Unemployment, \*Cost-benefit theory. Identifiers: Factor price, \*Excess capacity, Synthetic response function.

Conventional cost-benefit analyses rest on an assumption that the economy is fully employed. This permits use of factor market prices or contract costs to measure the opportunity cost of public works projects. In the post-war period unemploy-ment has tended to remain above the frictional rate. Conditions that existed during the period 1957-64 raise the question as to the validity of using a full employment assumption. This could lead to a significant divergence between real cost and contract costs. Twelve types of water resource projects were investigated. Unemployment rates by occupational categories and the degree of capacity underutilization were examined to determine the extent to which projects would draw on idle pools of occupational skills and industrial capacity. Synthetic response functions, relating the probability of employing otherwise idle resources to the degree of unemployment were constructed intending to bracket the probable response. Based on the unemployment rate and capacity utilization (1960 representing the 1957-64 period), the real cost of project construction would have been about 25% less than contract costs. W68-00165

# WATER POLICY AND ECONOMIC OPTIMIZING: SOME CONCEPTUAL PROBLEMS IN WATER RESEARCH,

California Univ., Berkeley S. V. Ciriacy-Wantrup.

American Econ Rev, Vol LVII, No 2, pp 179-189. May, 1967. 11 p, disc.

Descriptors: Water law, Groundwater surface waters, \*Decision making, Cost-benefit analysis,
\*Multipurpose projects, \*Institutions, California. Identifiers: Wright Act, \*Integrated waterresources system.

Recent literature is concerned mainly with the public multipurpose development of surface water. This particular water system is less significant in inputs and outputs than other systems and is always closely related to others as part of an integrated system. However, the decision rules suggested for this susbystem are neither valid nor relevant for the integrated system. In the later, groundwater use is quanitatively at least as significant as surface water use. Groundwater is developed largely by private rather than by public investment. The decision-making process for such an integrated system could be divided into three levels. The first level relates directly to the control of inputs, outputs and other quantitative characteristics. The second controls the institutional framework of the first level. Its function is not to maximize economic efficiency but to structure the decision-making on the lower level. For example, this would permit careful institutional analyses of the water law rather than reiterate that the law failed at optimization of water development or allocation. The third decision level, implied by reference to the constitutional organization of the U S, sets the basic framework for water policy W68-00168

# WATER RESOURCES AND REGIONAL ECONOMIC GROWTH IN THE UNITED STATES, 1950-1960.

Resources for the Future, Washington, DC. Charles W. Howe. Southern Econ Jour, Vol XXXIV, No 4, pp 477-489, April 1968. 13 p, 8 tab, 15 ref.

Descriptors: Streamflow, Runoff, Employment, \*Regions, \*Growth rates, Sites, Water supply. Identifiers: Partitioning, \*Water availability, Analysis of variance.

It was found that water did not constitute a bottleneck to rapid growth in the major water deficit areas, and plentiful supplies failed to raise the growth rate of the midcontinent water surplus areas close to the national average. Counties contiguous with the inland waterways and Great Lakes exhibited growth rates substantially below the national average, while coastal areas grew at rates far above the national average. When regional growth rates are taken as norms, on the assumption that non-water factors account for interregional differentials in growth rates, it is found that waterway contiguous counties grew faster than others in the same region in all mid-continent regions. The opposite was true for coastal regions. Stream flow and runoff failed to show any relationship to growth rates. The evidence indicates water availability does not outweigh other attributes possessed by re-gions which make them attractive to industrics. W68-00169

# THE RISK OF DAMAGE TO WATER RESOURCE PROJECTS BY UNUSUAL PHYSI-CAL OCCURRENCES,

D. C. Williams, and D. L. Daniel.

Mississippi State Univ., Water Resources Research

Descriptors: \*Risk, Expected value, Short-term and long-term projects.

Risk is a crucial element in many water-resource projects, yet no satisfactory methods have been developed to determine the level of justifiable risk. To aid in alleviating this hiatus, attention was devoted to developing a workable general theory from an economic standpoint. Water-resource projects are categorized in relation to damage from

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unusual physical occurrences, such as hurricanes, 'long-term' and 'short-term' projects. Implications were outlined for the time period on the risk involved and an evaluation was made of risk in both 'long-term' and 'short-term' Procedures are presented for determining the level of justifiable risk in both cases. These procedures proved to be less precise for the short-term than for the long-term case. Factors discussed include: (1) a critical evaluation of the use and applicability of the expected value approach, (2) the criterion for determining whether a project is 'long-term' or 'short-term', and of the importance of accurate probability of occurrence estimates versus the possibilities of obtaining such estimates. In situations characterized as long-term, and expected value approach is applicable. In short-term cases, the question of what level of risk can justifiably be assumed could not be answered.

# THE EFFECTS OF GEOGRAPHICAL AND CLI-MATIC SETTING ON THE ECONOMIC AD-VANTAGES OF ALTERNATIVE FLOOD CON-TROL MEASURES,

Kentucky Univ., Lexington. Clyde R. Dempsey.

Research Rept 10, Kentucky Water Resrcs Inst, Lexington, 1968, 166 p. 26 fig, 45 tab, 32 ref, 5 ap-

Descriptors: \*Hydrographs, Streamflow forecasting, Time lag, \*Flood control, Channel improvement, \*Non-structural alternatives, Flood plains, Flood proofing, Flood plain zoning, Land use, Project planning, Economic justification, Scheduling, Digital computers, \*Urbanization, Climatic zones,

Geographical regions. Identifiers: \*Urban hydrology, Holding right-of-way, Louisville, Ky, Sacramento, Calif, Stanford Watershed Model.

Selection of the economic optimum combination of flood control measures by stage throughout project life and by location within the flood plain requires evaluation of the effects of urban development and channel improvement on the peak, volume, rising time, and shape of the flood hydrograph. Through application of the Stanford Watershed Model to a given watershed before and after an extensive period of urban development and channel improvement, a series of curves were developed for determining each of the effects on flood hydrographs. The end product is a computer program capable of generating flood hydrographs appropriate for any typical watershed surface, drainage area, urban development, and degree of channel improvement. Values are developed and compared between California and Kentucky to obtain some idea as to the effects of geographical and climatic setting on the results. The method of hydrograph generation is applied to an economic analysis of the optimum combination of structural and non-structural flood control measures within South Jefferson County, Kentucky. W68-00186

# WHERE DOES THE BEACH BEGIN, AND TO WHAT EXTENT IS THIS A FEDERAL

QUESTION, Washington Univ., Seattle. School of Law Charles E. Corker Wash L Rev, Vol 42, No 1, pp 33-118, Oct 1966.

Descriptors: \*Beaches, Judicial decisions, Tides, \*Boundaries (Property), \*Boundary disputes, Jurisdiction, \*Accretions (Legal aspects), \*Shores, Intertidal areas, Washington, High water mark. Identifiers: \*Vegetation line.

An examination of judicial determinations as to the location of the boundary of land abutting tidal waters is made. Washington and general law are discussed. The courts are divided as to: (1) Whether the correct boundary should be the vegetation line of the mean high water mark (2)

What constitutes the mean high water mark (3) When the boundary determination should be made (4) The relationship of state and federal law in making this determination. The vegetation line is that line below which the flow of the tide will not permit vegetation to grow. The mean high water mark is generally the average of all high tides computed over a complete 18.5 year tidal cycle. The discussion necessarily involves a determination of ownership of accretions to land bordering tidal waters. Generally accretions belong to the owner of the land bordering the tidal water. The relative desirability of having a boundary fixed as of a point in time and having the boundary change with accretion is discussed. W68-00192

#### BOUNDARIES--'THREAD OF THE STREAM'--THE KENTUCKY RULE,

Kentucky Univ., Lexington. James F. Miller.

Ky L J, Vol 44, pp 466-470, Summer 1956. 5 p, 17

Descriptors: \*Kentucky, \*Boundaries (Property), Low water mark, Legal aspects, Judicial decisions, Ownership of beds, Rivers, Streams, Riparian rights, Channels.

The case of Louisville Sand and Gravel Co. v. Ralston, 266 S. W. 2d 119 (Ky. 1954), brought Kentucky into the view held by nearly all jurisdictions and authorities as to what constitutes the 'thread of the stream'. This case held that thread of the stream means the center line of the stream as measured from the low water mark on one shore to the corresponding low water mark on the opposite shore. In prior cases it had been held that thread of the stream meant the center line of the main channel. While this latter concept would work if strictly adhered to, the center of the stream is likely to be a more stable line for boundary purposes. The procedure for locating the center line by using low water marks is a minority view, but perhaps the sounder one. The majority rule measures from the water mark at ordinary stage, but since the purpose of the establishment of the thread of the stream is to give riparian owners rights in stream beds for access to water, a line measured at ordinary stage might be completely out of the water at low stage. W68-00196

#### WATERS AND WATERCOURSES--RIPARIAN RIGHTS--EXTENT OF OWNER'S TITLE,

West Virginia Univ., Morgantown. Samuel R. White, Jr.

W Va L Rev, Vol 53, No 1, pp 96-99, Dec 1950. 4

Descriptors: \*West Virginia, Legal aspects, Judicial decisions, Water level fluctuations, Riparian land, \*Boundaries (Property), Boundary disputes, \*Low water mark, Ownership of beds, Riparian

rights.
Identifiers: Ordinary low water mark.

In the West Virginia case of Carpenter v. Ohio River Sand and Gravel Corp., 60 S. E. 2d 212 (W. Va. 1950), it was held that the title to a riparian owner's land extends to the low water mark, which is the lowest point to which the water has ever receded. There is a split of authority among the jurisdictions as to whether a riparian's title extends to the high water mark or the low water mark. In those jurisdictions holding that title extends to the low water mark, that mark is almost unanimously held to be the ordinary low water mark. Extending a riparian owner's title to the lowest mark the water has ever receded can perhaps be justified by preserving the riparian's right of access to the water in all cases. If title extended only to the ordinary low water mark, there would be times when the water would recede further, leaving a strip of land between the riparian owner and the water. W68-00197

#### DEPARTMENT OF WATER AND AIR RESOURCES.

Michie Co., Charlottesville, Va.

N Car Gen Stat (1964) (Supp, 1967), Vol 3C, pp 43-78, sec 143-211 to 143-215.37, 36 p.

Descriptors: \*North Carolina, \*Water pollution control, Legislation, \*Water resources development, Water utilization, Administration, Consumptive use, Standards, \*Water allocation (Policy), Classification, Permits, State governments, Regula-tion, Dams, Air pollution.

Part 1 of this act creates a Board of Water and Air Resources (the Board) to administer a program of water and air pollution control and water resource management in North Carolina. The Board is empowered to adopt classifications and standards for all waters of the state. A permit system is created for the regulation of any new addition to or construction of a waste disposal system. Previouslyconstructed systems in violation of established standards may be required to comply with these standards by the issuance of special orders. The act also describes the general powers of the Board, provides for judicial review of its final actions, and lists acts which are violations and their resulting penalties. Part 2 concerns the regulation of the use of water resources and provides for designation of capacity use areas, regulations and permits within such areas, and penalties for violations of this Part's provisions. Part 3 is a dam safety law and requires approval of the Department of Water Resources prior to any construction, repair, alteration, or removal of a dam. The Board is given power to inspect the maintenance and operation of such dams. W68-00199

#### CURRENT TRENDS IN WISCONSIN'S WATER LAW,

Wisconsin State Bar, Madison.

J. H. Beuscher.

Wisc Bar Bull, Vol 40, No 2, pp 19-28, Apr 1967. 9

Descriptors: Wisconsin, \*Repulsion (Legal aspects), \*Surface runoff, Reasonable use, Ripari-(Legal an rights, \*Groundwater, Artificial watercourses, Natural streams, Ownership of beds, Navigable waters, Avulsion, Accretion (Legal aspects), Legislation, \*Judicial decisions, Public rights.

A summary of recent cases, legislation, and trends in Wisconsin's water law. Wisconsin courts still apply the common enemy rule to diffuse surface water, which is criticized as being unjust in many circumstances, even though it may have the advantage of certainty. Remedial legislation to alter the rule to require reasonable conduct in disposing of diffuse surface water is recommended. The courts in Wisconsin do not follow the reasonable use doctrine, but still hold that ground water is the absolute property of the land owner. Finally, the riparian law of lakes, streams, and ponds as affected by the courts and legislature is discussed. Included were recent court decisions on the ownership of artificial lake beds, ownership of beds of navigable streams and the public trust doctrine, the filling in of navigable strams, and amulsion and accretion of rivers. The Water Resources Act of 1966 (Chapter 614, Laws of 1965-66) was analyzed in some detail in the areas of stream standards, subsidy programs and tax incentives, shoreland protection, septic tank controls, additional sanctions against polluters, and compulsory certification of waterworks and sewage treatment opera-W68-00202

THE HIGH WATER MARK: BOUNDARY BETWEEN PUBLIC AND PRIVATE LANDS,

Florida Univ., Gainesville. Norwood Gay.

U Fla L Rev, Vol 18, No 4, pp 553-576, Spring 1966. 24 p, 107 ref.

# Cost Allocation, Cost Sharing, Pricing/Repayment—Group 6C

Descriptors: \*Boundaries, \*High water mark, Ownership of beds, \*Shores, Regulation, Riparian rights, Bulkhead lines, Bulkheads, \*Tides, \*Florida, Legislation. Identifiers: Tidelands, Filling, \*Submerged lands.

This article examines the technical complexities surrounding the establishment of the high water mark and the legal significance of the boundary as it affects private and public property rights. Private ownership of land bordering on navigable waters extends only to the high water mark. Tide patterns and their importance in determining the high water mark are discussed. The usual method used by a land surveyor to locate the high water mark is explained. The right of sovereignty and property in tidelands was acquired by Florida upon admission to the Union. Means of conveying state owned tidelands were set out in the Riparian Act of 1856 and the Butler Bill of 1921. These acts required bulkheading and filling by purchasers of submerged lands to perfect title. In 1957 the legislature passed the Bulkhead Laws. These laws provide for the setting of bulkhead lines by appropriate government authorities to regulate the filling of submerged lands in light of both private and public rights, including conservation. The development of ease law under each of the above acts is traced. W68-00204

# SELLING RECLAMATION WATER RIGHTS--A CASE STUDY IN FEDERAL SUBSIDY POLICY, Michigan Univ., Ann Arbor.

Joseph L. Sax

Mich L Rev, Vol 64, No 1, pp 13-46, Nov 1965. 34 p, 107 ref, disc

Descriptors: \*Land reclamation, Irrigation, Crop production, Land development, Administration, Administrative agencies, \*Federal reclamation law, Irrigation districts, \*Project benefits, Benefit sharing, Cost repayment, Federal government, Legislation Publisher Costs \*Insertable Pu tion, Public benefits, \*Incremental income, Arid lands, Construction costs.

The federal reclamation program was designed to provide farmers with irrigation water at prices they could afford. Since the worth of such a water right is reflected in land values, one who sells a farm in a reclamation project may also receive payment for this right. Since the asset marketed was created by the investment of public funds in the construction of the project, the effect is that the seller converts the reclamation subsidy into cash at the expense of the successors on the project. The article contends that this problem exists due to the federal governments reluctance to impose price controls on the sale of reclamation water rights. The reasons for this reluctance are discussed and rejected. Reclamation legislation is traced that indicates the federal government is not adverse to imposing price controls on incremental value in the case of speculation and it is suggested that Congress simply has not faced up to the task of distributing the in-cremental value among bona fide settlers. The article contends that retention of the incremental value within the project is the most equitable solution. This may be accomplished by allowing the irrigation district to recover the profits.

W68-00205

#### DISTRICTS AFFECTING WATER USE AND CONTROL.

Iowa State Univ., Iowa City. Robert L. Smith

lowa L Rev, Vol 41, No 2, pp 181-197, Winter 1956. 17 p, 29 ref.

Descriptors: \*Iowa, Water districts, Legislation, \*Water resources development, Governments, Institutional constraints, Multiple-purpose projects, Water control, Water utilization.

A general review of past development, together with certain possible future considerations, associated with district efforts toward water use and control. The limiting factors in the development of water use and control projects are physical, economic, or institutional considerations. These three must be integrated in order to solve water problems, and often this cannot be accomplished by individual action, but can be accomplished by district organization. The basic elements included in current majority rule type of legislation for districts are: (1) procedures to be followed in organizing, establishing, and financing the district; (2) authority to extend operations across existing authority to extend operations across existing political boundaries; (3) authority to execute future maintenance work; and (4) provisions to coordinate the efforts of individual districts via some method of technical supervision or review. A vast majority of district legislation is directed at the solution of one physical problem. Future districts should be organized as multi-purpose efforts. Both special assessment districts and the governmental approach to water control through general taxation will continue in the future, but ascertainment of suitable economic principles for development of more realistic districts is needed. W68-00224

#### TITLE TO SUBAQUEOUS LANDS ALABAMA,

Alabama Univ., School of Law. C. M. A. Rogers, III. Ala L. Rev, Vol 11, No 2, pp 273-288, Spring 1959. 16 p, 95 ref.

Descriptors: Boundaries (Property), Judicial decisions, Legislation, Submerged Lands Act, \*Ownership of beds, Public rights, Riparian land, \*Water law, \*Riparian rights, Watercourses (Legal), \*Alabama, High water mark, Low water mark, Bodies of water, Beds, Navigable waters, Non-navigable waters, Tidal waters.

The historical development of Roman, English, and early American law as it pertains to title to sub-aqueous land is first set forth. Since each state has the same rights as the original states in navigable waters and the lands underlying them, the question of ownership of subaqueous lands is one of purely local law. With this background, the law as it developed in Alabama is examined. Ownership of land underlying marginal seas and tidelands is discussed, concluding that title to both is vested in the state. Cases dealing with ownership of river and stream bottoms are analyzed. If a lake or pond is navigable, title to the bed is vested in the state; if non-navigable, title is in adjoining landowners. The meaning of navigability is examined, concluding that the test of navigability of fresh water rivers in Alabama is one of navigability in fact. The test with regard to tidewaters is whether the land is subject to the ebb and flow of the tide. The power of the state to alienate its subaqueous land is discussed in relation to the public trust doctrine. W68-00229

# FEDERAL POWER COMMISSION CONTROL OVER RIVER BASIN DEVELOPMENT. Virginia Univ., Charlottsville.

U Va Law Rev, Vol 51, No 4, pp 663-685, May 1965. 23 p, 118 ref.

Descriptors: Resource allocation, \*River basin development, Electric power demands, Administrative decisions, Judicial decisions, \*Federal trative decisions, Judicial decisions, Federal Power Act, Hydroelectric plants, \*Hydroelectric project licensing, Beneficial use, Water resources development, Electric power industry, Electric power production, Water utilization, Regulation. Identifiers: \*Federal Power Commission.

The adequacy of the present jurisdiction and policies of the Federal Power Commission for the achievement of sensible and comprehensive river development are examined in the light of past failures and new opportunities for effective regulation. The FPC was created in order that there may be a unified federal policy on water use. This objective requires that licensing authority be established over all significant power installations. Recent Supreme Court decisions construing the FPC's authority to extend to all installations affecting any interest of national commerce are significant. The FPC policy of favoring power expansion over other possible uses for water resources is justified by the demands of rapid economic growth. The FPC uses its broad authority to protect conservationist interests such as fish resources by requiring licensees to maintain their plants to the advantage of such interests. The problem of protecting the natural beauty of unspoiled areas is more difficult and may be ultimately irreconcilable with the policy of developing power at the lowest possible costs. It is concluded that, given legislative and judicial support, the FPC can now begin to play the role for which it was intended, despite past failures. W68-00238

# WATER BASED RECREATION IN NEVADA: WESTERN DESERT AND NORTHERN LAKES, University of Nevada, Reno. George A. Myles. Univ of Nevada, Coll of Agr, Bull B14, March 1967. 74 p, 22 tab, 4 fig.

Descriptors: Nevada, \*Recreation facilities, Recreational use, \*Lakes, \*Reservoirs, Boating, Fishing, Camping, Swimming, Water skiing, Tourism, Water sports, \*Recreation demand.

study of Nevada's water-based recreational facilities was conducted, June 18-Sept 10, 1965, by 7 students from the University of Nevada. It included Lakes Tahoe, Pyramid, Topaz, Walker and Lahontan Reservoir in the west; Rye Patch and Wildhorse Reservoirs, Ruby and Angel Lakes in the north, and Lakes Mead and Mojave in the south. Information sought covered use of waterbased recreational facilities, satisfaction with or desire for facilities and services, public willingness to be charged for use of areas and facilities, expenditures of visitors and characteristics of visitors which affected demand for facilities, areas and services. Reviews and summaries of reports for each of the above lakes, except Lakes Mead and Mojave and Lake Tahoe which are covered in separate volumes, were given. On the basis of the findings, recommendations included charging of high prices for facilities with exclusive features for higher socio-economic groups and nominal fees for those of lower groups satisfied with fewer services; facilities for younger aged groups; a wide variation of facilities where feasible; more definitive directions for tourists; insect control; and more accurate estimates of visitor numbers. W68-00308

## 6C. Cost Allocation, Cost Sharing, Pricing/Repayment

ARE INDIVIDUAL RATINGS NECESSARY. **CURRENT-METER** 

US Geological Survey. George F. Smoot, and Rolland W. Carter. ASCE Proc, J Hydraul Div, Vol 94, No. HY2, Pap 5848, pp 391-398, Mar 1968. 8 p, 5 tab.

Descriptors: \*Standards, Open channel flow, Measurement, \*Hydraulics, \*Calibrations, Current meters, Instrumentation, Velocity, Data collections, Variability, Evaluation.

Identifiers: \*Price current meters, \*Rati procedure, Bureau of Standards, Standard errors

Price current meters used by the U S Geological Survey are calibrated individually at the National Bureau of Standards. Calibration data for 3 groups of meters from 3 different manufacturers were studied to determine the feasibility of continuing this practice. No significant difference was found between the standard error of individual ratings and the standard error of an average rating for a group. New standards for the manufacture, calibration, and use of Price current meters are proposed. W68-00043

# Group 6C—Cost Allocation, Cost Sharing, Pricing/Repayment

WATER MANAGEMENT LEGISLATION IN THE EASTERN STATES,

Wyoming Univ., Laramie. Milton S. Heath, Jr.

Land and Water L Rev, Vol 2, No 1, pp 99-116, 1967. 18 p, 2 fig, 45 ref.

Descriptors: \*Water allocation (Policy), Water law, Legislation, Administration, Surface runoff, Regulation, \*Groundwater, Legal aspects, \*Surface water, Water utilization, Consumptive use, Water policy.

Recently, several Eastern states have made substantial inroads on traditional riparian doctrines concerning surface and ground water. A number of states have enacted or are considering less extensive legislation, and a few states are beginning to develop sources of water supply for specific uses. Cyclical drought conditions and population and industrial growth are the two major factors in the recent development of Eastern water law. The types of regulatory measures currently on the statute books of Eastern states are classified as 'limited', 'moderate', and 'strong', in order to convey an over-all impression of the status of Eastern regulation today. A detailed review of selected laws makes up the remainder of the article. The principal types of allocation laws present in the strong new ground and surface water laws, miscellaneous other legislation concerning ground and surface waters, and legislation for diffused surface water are detailed. Most Eastern states with legislation concerning use of diffused surface water have confirmed the common law rule of absolute ownership. Recent proposals have leaned toward other solutions, such as using a rule of reason or making diffused surface water subject to permit-type regulation. W68-00117

IS PUBLIC INTERVENTION IN WATER RESOURCES DEVELOPMENT CONDUCIVE TO ECONOMIC EFFICIENCY,

New Mexico Univ. School of Law, Albuquerque.

John V. Krutilla. Natural Resources Journal, Vol 6, No 1, pp 60-75, Jan 1966. 16 p, 1 tab, 25 ref.

Descriptors: \*Welfare (Economics), Input-output analysis, \*Cost-benefit analysis, Cost-benefit ratio,
\*Interest rate, Marginal return, Investment, \*Economic efficiency, Marginal costs, Average costs, Income, Reimbursable costs, resources development.

The history and precepts of welfare economics is presented and related to the necessity of public intervention. Efficiency was the end of intervention. The Treasury Federal Reserve Accord in 1951 and a change in national administrations prompted increased interest in the water resources field. Interest rates and cost-benefit analysis are discussed. The article contains a table comparing yields of government securities and computed coupon rates.

A discussion of economic evaluation and reimbursement is related to economic efficiency. An analogy to management of the Ruhr in Germany is used. A separate action considers the governmental agency as a medium of public intervention. A reassessment of public intervention machinery is proposed in the conclusion. W68-00127

COST DEPLETION OF GROUNDWATER. Stanford University, Stanford. John H. Messing Stan L Rev, Vol 18, No 4, pp 1229-1236, May 1966. 8 p, 41 ref.

Descriptors: \*Groundwater, Reservoirs, Water consumption, Water utilization, \*Taxes, Costs, \*Water costs, Capital costs, Federal Government, Legal aspects

Identifiers: \*Cost depletion

United States v Shurbet, 347 F. 2d 103 (5th Cir. 1965), decided for the first time the question of whether groundwater is the subject of cost depletion. The case held that groundwater extracted from the Ogallala reservoir and used for irrigation was eligible for cost depletion, but only in light of the peculiar conditions of the case. The Internal Revenue Service announced that it will follow the decision only for water extracted from this reservoir. The article poses two questions: whether groundwater is a depletable resource, and if so, under what conditions depletion is or should be available. The issue of cost depletion for groundwater depends on whether water falls within one of the categories of section 611 of the Internal Revenue Code of 1954. After examining the opposing arguments, it is concluded that groundwater is a depletable resource. If this conclusion is correct, then whether depletion is available for a particular accumulation of groundwater depends upon the nature of the taxpayer's investment, the character of the deposit, and the use made of the water. Each of these factors is analyzed, and additional depletion allowances are suggested. W68-00131

GOVERNMENTAL REFILLING OF LAKES AND PONDS AND THE ARTIFICIAL MAINTENANCE OF WATER LEVELS: MUST JUST COMPENSATION BE PAID TO ABUTTING LANDOWNERS,

Texas Law Review, Austin. Robert E. Beck.

Texas L Rev, Vol 46, No 2, pp 180-212, Dec 1967. 33 p, 113 ref.

Descriptors: \*Accretion (Legal aspects), Boundaries (Property), Lakes, Ponds, Water level fluctuations, \*Water levels, \*Water policy, \*Eminent domain, Judicial decisions, State governments, Watercourses (Legal), \*Riparian rights, \*Riparian land, Boundary disputes, Water law.

The article analyzes three questions in determining whether and under what circumstances the state government may carry out a program of artificial maintenance of a high water level without the necessity of compensating abutting landowners. (1) Whether there is a littoral right to alluvion property. A court may take either a lump-sum or a selective approach to the various littoral rights. If a selective view is taken, then the right to future alluvion may or may not be a vested property right.

Cases and policy on both sides of the issue are discussed. The additional question of the time when alluvion may form and cause a clear vested right to arise is examined in some detail. (2) If alluvion is property, whether there has been a taking or damaging. The two primary arguments generally available to the government on this issue, one based on the state's interest in the water and the other on the state's ownership of the underlying bed, are discussed. (3) What is the measure of just compensation. Difficulties inherent in determining such a measure are brought out. The article closes with a brief summary and a conclusion. W68-00138

GROUND WATER--DEPLETION OF A WAST-ING ASSET, Southern Methodist Univ. School of Law, Dallas.

Ronald L. Palmer. SW L J, Vol 19, pp 791-800, 1965. 10 p, 51 ref,

Descriptors: \*Ground water mining, Resevoirs, Water table, \*Taxes, Income, Water level fluctua-

Identifiers: Cost depletion allowance.

In United States v. Shubert, 347 F. 2d 103 (5th Cir. 1965), the Court held that water removed from a ground water resevoir beneath the taxpayer's property and used to irrigate crops was a 'natural deposit' within the meaning of federal income tax statutes and permitted the taxpayer to take a costdepletion allowance for water removed. The court limited its determination to the particular facts of this case where the water had been trapped in a

natural resevoir, there was no appreciable replenishment, the taxpayer was able, with reasonable certainty, to measure the water table decline beneath his property, and establish the required cost basis of the resevoir. The note points out, however, that the court failed to decide several crucial issues, such as: (1) Is production necessary; or will the taxpayer qualify where the water declines by natural means or a neighbors drainage. (2) If production is required, must it be pursuant to income producing activity. (3) Is there a limit on the disproportionality allowable between income and depletion calculated by decline in water level. (4) Will other minerals qualify as 'natural deposits' for depletion purposes. W68-00147

URBAN WATER SUPPLY: A SECOND LOOK, California Univ., Los Angeles, Indiana Univ., Bloomington.

Jack Hirshleifer, and J. W. Milliman.

American Econ Rev, Vol LVII, No. 2, pp 169-178, May, 1967. 10p, 4 tab, 12 ref, disc.

Descriptors: \*Discount rate, Pricing, Marginal Costs, Storage capacity, \*Elasticity of demand, \*Water requirements, New York, California, Hudson River.

Identifiers: \*Cannonsville Dam, \*Feather River Project.

There has been consistent overpricing and over-building in regards to urban water supplies. Reallocation of existing supplies by use of flexible prices is rarely considered. This is due to political and legal influences and to faulty economic reasoning. There is a belief in certain inelastic needs for water, rather than in economic demands, even though sensitivity to price changes has refuted this. For New York in 1960 it was contended that metering and leakage control were economic substitutes for the proposed Cannonsville Dam, and that even a dam on the Hudson would have been cheaper. It is also believed that the proposed dam would have been of little assistance during the 1965 water shortage. The idea of California building the Feather River Project in 1960 was deemed premature. There were already excessive supplies, and rate increases as well as reallocation from agriculture and wastes would have been cheaper. As a result the area's water wholesaler, the Metropolitan Water District, was pressured into buying this enormous supply of high cost water from the state. As a result area costs should be \$58 an acre foot by 1975 (as compared to \$15 in 1960), and \$26 for agriculture (up from \$12 in 1960). W68-00166

NONMARKET VALUES AND EFFICIENCY OF PUBLIC INVESTMENTS IN WATER RESOURCES, WATER

Michigan State Univ., East Lansing. Allan A. Schmid.

American Econ Rev, Vol LVII, No 2, pp 158-168, May, 1967. 11 p, disc.

Descriptors: Efficiencies, Welfare, Optimization, \*Intangible benefits, \*Pricing, Environmental effects, Alternative costs.

Identifiers: Public good, \*Externalities, Pareto op-

Predictive purposes require pricing the benefits of the intangible goods and incommensurable goods derived from water resources: any use of resources involves an opportunity cost. An exchange ratio exists even if no trade occurs, since an alternative has been foregone. When it is said that the benefits of some goods cannot be measured, what is really meant is that we are ignorant of their desired characteristics or utility. Water with different chemical and biological content could be considered as different products and each product would have different cost and demand schedules whose interactions would be analyzed. In the case of externalities we know only that a Pareto-better trading possibility exists. For example, a water owning firm does not know some fisherman would pay for pollution reduction, and a trade beneficial to both parties is not negotiated. Externality theory is not useful for questions of the property right to a resource that becomes newly useful. For new nonmarginal public goods neither the cost nor value are known, since opportunity cost is a function of derived product prices. Empirical analyses could allow the decision on the ultimate impact of these investments to be left to the public. W68-00167

APPLICATION OF MARGINAL ECONOMIC ANALYSIS TO RESERVOIR RECREATION PLANNING,

Kentucky Univ., Lexington.
John Ellis Sirles, III.
Research Rept 12, Kentucky Water Resrcs Inst,
Lexington, 1968, 99 p, 14 fig, 19 tab, 31 ref.

Descriptors: \*Recreation, Psychological aspects, \*Recreation demand, Recreation facilities, \*Recreation demand, Recreation facilities, Economic efficiency, Planning, Water resources development, Project planning, Cost comparisons, Marginal benefits, \*Marginal costs.

Identifiers: \*Recreation visitation.

Recreation visitation and facility cost data were analyzed for 3 reservoirs in the Ohio River Valley to derive a method for selecting the optimum level of recreation facility development by marginal economic analysis. The visitation data were used to determine factors expressing the time distribution of facility use over the day, week, and year and the number of recreation visitors who could be accommodated per unit area. The facility cost data were used to estimate annual cost and marginal cost as functions of annual visitation. The marginal cost curve was found to have a characteristic U shape and depend on the size of the facility and the density of the surrounding population. Potential visitation to a large facility was estimated and converted to a potential benefit by a unit value based on travel cost. A method was developed for estimating actual visitation to a smaller facility as limited by size restrictions. The costs of providing a larger facility could then be compared with additional benefit from the greater number of visitors attracted to select the optimum facility size. W68-00188

COMPENSATION FOR FLOWAGE EASE-MENT--RECENT DEVELOPMENTS, Mercer Univ., Walter F. George School of Law,

Macon, Georgia. Willard C. Wheeler. Mercer L Rev, Vol 13, No 2, pp 416-420 Spring 1962. 5 p, 35 ref.

Descriptors: \*Eminent domain, \*Compensation, Federal government, Navigable rivers, Condemnation, Easements, Judicial decisions, Legal aspects, Hydroelectric plants, \*Condemnation value, Riparian land.

Identifiers: \*Flowage easement, Flood Control Act.

A judicial formula to ascertain the amounts of compensation due an owner of riparian land over which a flowage easement has been condemned by the Federal government is given. The government condemned a flowage easement over land in which respondent held a perpetual and exclusive flowage easement. The only question was the proper amount of compensation. The U.S. Supreme Court held the proper value of the land to be the nonriparian value of the servient land discounted by the improbability of the easements exercise, excluding consideration of the prospect of govern-mental appropriation or such depreciation in value as the prospect of governmental taking might cause. Thus, the availability of the lands for water power was not considered in determining fair market value. The U. S. holds a dominant servitude in all navigable streams but this servitude does not extend beyond the bed of the river. Land without the dominant servitude is compensable. Both the Federal government's power to regulate commerce and the general welfare power are involved.

W68-00233

COMPENSATION FOR POTENTIAL POWER SITE VALUE OF LAND CONDEMNED PURSUANT TO EXERCISE OF NAVIGATION SERVITUDE.

Columbia Univ. Law School, New York.

Colum L Rev, Vol 56, pp 795-798, May 1956. 4 p,

Descriptors: \*Condemnation, \*Condemnation value, Compensation, Legal aspects, Riparian land, \*Riparian rights, Navigable rivers, Flood control,

Multiple-purpose projects.
Identifiers: \*Navigation servitude, Constitutional

When the United States condemns uplands surrounding a stream for purposes which include the improvement of navigation, just compensation does not include any special value of the land eased on utilization of the natural flow of the stream. The owner of riparian rights on navigable interstate waters holds these rights subject to a navigation servitude in the United States to appropriate them without compensation in the exercise of its exclusive control over navigable interstate waters. Thus, no compensation for riparian rights appurtenant to the uplands is included in the condemnation award. The exercise of the navigation servitude has now been extended to situations where the improvement of navigation is only an incidental benefit to the main purpose of the project, such as flood control or development of power. Further, clear authorization by Congress is no longer necessary to the exercise of the navigation servitude. W68-00236

A SOCIALLY OPTIMUM PRICING POLICY FOR A PUBLIC WATER AGENCY, University of Washington, Seattle, Wash; University of California, Berkeley, Calif. Gardner Brown, Jr, and C. B. McGuire. Water Resources Res, Vol 3, No 1, pp 33-43, 1967. 11 p, 5 tab.

Descriptors: \*Water policy, Water resources, Irrigation districts, Water supply, Water demand, Water rates, Tax rate, \*Social aspects, \*Water allocation (Policy), Cost allocation. Identifiers: Kern County, Calif.

The Kern County Water Agency, one of the principal contractors for water in the first stage of the California water plan, is a model for determining the socially optimum price to charge irrigation districts for surface and groundwater supplies. A stable environment is assumed with respect to groundwater conditions and water demand functions. The existence of unadjudicated rights to groundwater supplies caused a divergence between social and private optimums. An appropriately conceived pumping tax achieved the social optimum. Water prices, tax rates and optimum lift levels are estimated for 7 mated for 7 irrigation districts, members of the master agency W68-00306

### 6D. Water Demand

THE FEDERAL RESERVED WATER DOCTRINE--APPLICATION TO THE PROBLEM OF WATER FOR SHALE OIL DEVELOPMENT,

Wyoming Univ., Laramie. Richard A. Hillhouse. Land and Water L Rev, Vol 3, No 1, pp 75-102, 1968. 27 p, 97 ref.

Descriptors: \*Oil shale, Water allocation (Policy), \*Colorado River Basin, Colorado, Utah, Wyoming, \*Federal reservations, \*Reservation doctrine, \*Federal-state water rights conflicts, Long-term planning, Land resources, Non-navigable waters, Resource allocation, Competing uses, Water rights, Water policy, Social values, \*Withdrawn lands. Identifiers: Colorado doctrine, \*Federal reserved water doctrine, \*Pelton Doctrine, Naval oil shale

Oil shale is located in arid regions; yet significant amounts of water will be required for the extraction of oil. One method of acquiring water rights for Governmental shale oil development is through an application of the federal reserved water doctrine. This gives the federal government power to reserve all non-navigable waters contiguous with public land, a power limited in that by creating a reservation the government can only withdraw that amount of water consistent with the purpose behind the withdrawal of the land from the public domain. State created water rights acquired after the reservation are subordinate to this federal power. The article concludes that the doctrine as applied to shale oil bearing land withdrawn for investigation by executive orders issued in 1916, 1924, and 1930, does not result in the reservation of water rights for its development, since this would not be in accordance with the purpose behind the reservation. An opposite conclusion is reached as to certain lands reserved for development by the Navy. However, the author finds that the policy of maximum beneficial utilization of water resources weighs against application of the doctrine to both W68-00102

INTRODUCTION TO WATER USE LAW IN NORTH CAROLINA,

North Carolina Law Review, Chapel Hill.

William B. Aycock. N C L Rev, Vol 46, No 2, pp 1-38, Dec 1967. 38 p, 170 ref

Descriptors: Surface runoff, Subsurface waters, \*Reasonable use, Water pollution, \*Administrative agencies, \*North Carolina, \*Water law, \*Water policy, Riparian land, \*Riparian rights, Riparian waters, \*Water permits, Watercourses (Legal), Water pollution control, \*Legislation, Natural flow doctrine, Ownership of beds.

Laws defining the rights of landowners in water resources and laws on water use designed to protect the public interest are examined in detail. Private rights concerning watercourses, diffused surface water, and underground water are first delineated. Riparian rights govern interests in watercourses and underground water where legisla-tion is inapplicalbe. North Carolina rejects the tion is inapplicable. North Caronna rejects the natural flow rule and instead follows the reasonable use rule. This rule is examined as it applies to diver-sion, detention or acceleration of flow, backups and pollution. The navigable-non-navigable dichotomy as it affects riparian rights, public rights, and bed ownership is discussed. Public interest in water use, unlike private rights in water resources, is governed primarily by legislation. The history of legislation prior to the Water Use Act of 1967, creating the Board of Water and Air Resources, is analyzed. The 1967 Act applies to surface and un-derground watercourses, and empowers the Board, derground watercourses, and empowers the bard, following specific and detailed procedures, to declare a 'capacity use area.' Water users in this area are required to secure a permit from the Board where the use is in excess of 100,000 gallons daily. Discretion in the Board to issue a permit is limited to consumptive uses. W68-00111

DRY COMMENTS ON WATER, New York County Lawyers Association, New

New York County Lawyers Association, New York.
J. K. Coleman.
N Y County B Bull, Vol 23, No 1, pp 9-14, 1965-1966. 6 p, 32 ref.

Descriptors: Competing uses, Reasonable use, Water shortage, Water utilization, Water pollution, \*New York, Water control, \*Water law, Water resources, Civil law, Legal aspects, \*Legislation, Natural flow doctrine, \*Riparian rights, State governments, Usufructuary right, Riparian land, Prior appropriation.

## Group 6D-Water Demand

Identifiers: Common-law doctrine.

The article focuses on New York's water resources problems and legislative attempts to cure the common law's inability to cope with modern water use problems. The common law doctrine of riparian rights, as distinguished from the civil law, prior appropriation, and interstate common law doctrines of riparian rights, prevails in New York. The common law doctrine is criticized as discouraging the most beneficial use of water by emphasizing the continued flow of streams, and by confining water rights to landowners adjacent to the stream. Further problems with the common law doctrine are found in the uncertainty involved in applying the reasonable use rule and in determining the extent to which water rights are vested property rights protected by the Federal Constitution. This uncertainty tends to discourage long-term investments in water uses. New York's experience with these problems, and the failure of the legislature to adequately deal with them, is examined. Control of the use of water by the issuance of permits to water users for prescribed periods of time is mentioned as one solution to these problems.

A STATE STATUTE TO PROVIDE CONTROLS FOR EQUITABLE DISTRIBUTION OF WATER. Harvard Student Legislative Research Bureau, Cambridge.

Harv J Legis, Vol 4, No 3, pp 399-419, June 1967. 21 p, 70 ref.

Descriptors: \*Beneficial use, Administration, \*Administrative agencies, Water resources development, Water utilization, \*Planning, Water law, \*Water policy, Water users, \*Legislation, Prior appropriation, Riparian rights, \*State governments, Water law, \*Water rights, \*Water permits.

The article suggests that an administrative system controlling the use and distribution of water, which effectively checks misallocation and pollution, can insure the best possible supply of water for the future. Inadequacies of the riparian and prior appropriation systems, along with expected advantages of the administrative approach, are set forth. Current water rights legislation is examined, and a 'model' water rights statute is proposed. Significant features of the proposed statute include the creation of a Water Resources Board to, among other things, gather information and administer a water permit system. Generally, permits limited to a ten year period are required for water uses exceeding 5000 gallons daily and are only issued for a beneficial use of water resources. Jurisdiction and powers-of the board, permit procedure, and rules for application, hearing, and judicial review are included in the proposed statute.

# PRIOR APPROPRIATION IN MISSISSIPPI--A STATUTORY ANALYSIS,

Mississippi State Bar, University. William M. Champion. Miss L J, Vol 39, No 1, pp 1-38, Dec 1967. 39 p, 203 ref

Descriptors: Mississippi, \*Prior appropriation, Administrative agencies, Domestic water, Legal aspects, Legislation, Priorities, Permits, Water law, \*Water allocation (Policy), Water transfer, Water

The purpose of the article is to examine Mississippi's prior appropriation act in the light of the state's riparian background, administrative interpretation of the act, western experience in prior appropriation, and to draw some conclusions as to its meaning. The act protects vested rights and imposes a permit system on applicants, but does not provide for continued exercise of riparian rights as such. The act, with a few exceptions, regulates only surface water other than diffused surface water. Two types of users are recognized: those whose use had commenced on or prior to the effective date of the

act (prior users), and those whose initial use was subsequent thereto (subsequent users). Prior users have priority over subsequent users, provided their claim is made on time. Rights may be subsequently lost or modified by forfeiture, abandonment, action of the Board for good cause shown, and by order of a court. These rights are not subject to loss by adverse possession or prescription, but are transferable under certain conditions. Some provision should be made to allow the appropriator access to the water source, since it is not required that his property be appurtenant to water in order to use it. W68-00128

# REVIEW OF DEVELOPMENTS IN WATER UTILITY LAW 1965-1966.

American Water Works Association, New York,

Journal American Water Works Association, Vol 59, No 3, pp 389-396, Mar 1967. 8 p, 45 ref.

Descriptors: \*Water Resources Planning Act, Federal Government, \*Rivers and Harbors Act, \*Legislation, \*Judicial decisions, Water pollution, Pollution abatement, Regulation, \*Public utilities, \*Water works, Administrative decisions, Administrative agencies, Water resources development. Identifiers: Water Resources Council, \*Private water companies, Water Pollution Control Admin.

This report briefly reviews 1965-1966 Federal and state case and statute law affecting water utilities. The most significant development this year was the enactment of a national program of legislation. The Water Resources Planning Act was passed creating a cabinet-level Water Resources Council which is to submit biennial assessments of the adequacy of water resources and effectiveness of related federal projects. The River and Harbor Act of 1965 contemplates federal construction and control of water treatment plants. The Water Quality Act of 1965 creates the Water Pollution Control Administration and increases federal abatement powers. These expanded federal programs present a challenge to the regulated water utility industry. Administrators of the federal programs do not want federal money to be funneled into the pockets of stockholders of private water companies. This overstates the problem, however, since federal grants to regulate water utility are considered grants in aid of construction and are not counted toward rate base valuation. State regulation is moving toward regulation by commission rather than by local authorities. Construction of competing facilities by a municipality is being recognized as simply another form of municipal condemnation. W68-00158

# EFFECTS OF FEDERAL LEGISLATION ON THE INVESTOR-OWNED WATER UTILITY, American Water Works Association, New York. Edward R. Healy.

Journal American Water Works Association, Vol 59, No 3, pp 285-289, Mar 1967. 5 p, 2 ref.

Descriptors: Federal government, Water supply, \*Public utilities, \*Legislation, Administrative agencies, Capital costs, \*Economics, \*Government supports, \*Water works, Economic impact, Direct benefits.

Identifiers: Subsidies.

New federal programs to subsidize public agencies supplying water services are threatening the existence of investor-owned water utilities. An amendment to the Consolidated Farmers Home-Administration Act of 1961 authorizes grants of up to 50% to public agenices serving rural areas. The Housing and Home Financing Administration has been created with power to make grants of up to 50% for the purchase of land for public works. The Public Works and Economic Development Act of 1965 provides for similar grants through the secretary of commerce for development of public works. Public Law 89-298 authorizes the Federal government to assist in the solution of water supply problems in the Northeast. Investor owned water

utilities are excluded under each of these programs. Present competition from government utilities is strong due to direct subsidies, low cost financing, and absence of tax liability. Possible methods of preserving the investor-owned water utility would be to provede direct government subsidies, or indirect subsidies in the form of low interest government loans, tax credits, or tax exemption on bonds issued by the investor owned utility. Unless changes are made the investor owned utility will be unable to compete with the federally subsidized government agency.

W68-00160

# DETERMINING WATER REQUIREMENTS FOR SETTLING WATER DISPUTES,

New Mexico Univ., Albuquerque. Harry F. Blaney, and Wayne D. Criddle. Natural Resources J, Vol 14, No 1, pp 29-41, May 1964. 13 p, 3 tab, 34 ref.

Descriptors: Colorado River Compact, Interstate compacts, \*Consumptive use, Southwest US, River basin development, Water law, Beneficial use, \*Water utilization, \*Water distribution (Applied), \*Water requirements, Water allocation (Policy), Irrigation programs, Water policy, Irrigation districts, Irrigation efficiency, Legal aspects. Identifiers: International agreements, \*Blaney-

Criddle formula.

Application of the Blaney-Criddle (B-C) formula for determining the consumptive use of water is discussed. Mean temperature and percentage of daytime hours are the factors used to determine a monthly consumptive use factor. This is in turn used to determine seasonal consumptive use in inches. The amount of water required for irrigation projects can be estimated by applying the B-C formula. In connection with adjudication of water rights the formula can be used to compute irrigation requirements and stream depletion for an entire river basin. Computations of water use for areas in several Western States have been made. Compact negotiations to provide for apportionment of river systems have made use of the B-C formula to determine water needs. Such data was used during compact negotiations between states in the upper Rio Grande, Pecos River and Colorado River basins. Several states use the formula to establish diversion allocations of agricultural water. The formula has been used in attempting to negotiate development plans for the Jordan River system in the Near East, and the Indus River between Pakistan and India. W68-00211

# THE MUENCH CASE: A BETTER TEST OF

NAVIGABILITY, Wisconsin Univ. Law School, Madison. John L. Edwards. Wis L Rev, Vol 1957, No 3, pp 486-494 May 1957. 9 p, 37 ref.

Descriptors: \*Navigation, \*Navigable waters, \*Public rights, Legal aspects, \*Wisconsin, Judicial decisions, State governments, Relative rights, Recreation, Aesthetics, Scenery.

The public right to use waterbody is dependent on whether or not the waterbody is found to be navigable. In Nuench v Muench v Public Service Comm, 261 Wis 492, 53 NW 2nd 514 (1952), the Wisconsin Supreme Court adopted a new test for navigability, broader than the old saw log or commercial value tests. Under the Muench test, if a stream is navigable in fact for any purpose whatsoever, and if any beneficial interests of the public whatsoever are served by the stream, public rights will be protected. The court held that public rights in a navigable stream for recreational purposes, including enjoyment of scenic beauty, is a legal right entitled to all protection given financial rights. A brief summary of other state tests of navigability is included. W68-00221

#### ROLE OF LOCAL GOVERNMENT IN WATER LAW.

Wisconsin Univ., Madison. Andre M. Saltoun Wis L Rev, Vol 1959, No 1, pp 117-141, Jan 1959. 25 p, 104 ref.

Descriptors: \*Wisconsin, \*Local governments, Legal aspects, Judicial decisions, Zoning, Riparian rights, Navigable waters, Utilities, Water works, Water law.

Identifiers: \*Public trust doctrine.

Local governments, acting as water utilities, as administrators of the public trust in navigable waters, and as regulators of riparian rights through zoning, provide examples of the great power and influence they can exercise over water law and water use in Wisconsin. Considerable law is made at the local level and no study is complete unless it considers the impact of local government on water laws. As a public utility, local governments regulate water use in times of shortages through ordinances, by requiring permits for private wells, and by levying surcharges to residents of unincorporated areas. Under the trust doctrine in Wisconsin, navigable waters are held in trust by the state for the public. The legislature can delegate powers of local legislative and administrative character to countries, such as boating regulations, but it is unconstitutional to entrust to them power to regulate matters of state-wide concern. While riparian owners ordinarily can take water for residential, commercial, agricultural, or industrial purposes, when local govern-ments restrict the use of the riparian land to one of these purposes by zoning, the riparian 'right' to take water for the other purposes is lost. W68-00225

WATER LAW IN WEST VIRGINIA, West Virginia Univ., Morgantown. Marlyn E. Lugar. West Va L. Rev, Vol 66, No 3, pp 191-218, Apr 1964. 28 p, 91 ref.

Descriptors: Beneficial use, \*Riparian rights, \*Reasonable use, Water rights, Natural flow doctrine, Natural use, Riparian land, Legal aspects, Remedies, Riparian waters, \*Water law, Water utilization, Judicial decisions, Percolating water, Underground streams, Surface waters, Watercourses (Legal), \*West Virginia, State governments.

An examination of the persons who have a right to use water and the quantity which may be legally used in West Virginia is presented. Since there are no statutory provisions in West Virginia, and case law is meager, conclusions are based on predictions of how the courts will decide these issues. West Virginia water law follows the riparian doctrine. Rights to use stream water are based on ownership of land through which the stream flows. Generally riparian owners are restricted to reasonable uses of stream water, but no cause of action will arise until an unreasonable use causes damage to a lower riparian owner. As to surface waters not connected with a stream, and percolating waters the rule seems to be that use is restricted only by the requirement that the use be reasonable and benefi-It is concluded that the predictions are reasonably accurate. It is recognized that some phases of the common-law doctrine of riparian rights tend to discourage new or expanded projects. The best solution may be to merge some facets of the prior appropriation doctrine with the riparian doctrine. W68-00227

PROBLEMS IN WATER USE AND CONTROL,

Iowa State Univ., Iowa City.

John F. Timmons. Iowa L Rev, Vol 41, No 2, pp 160-180, Win 1956. 21 p, 34 ref.

Descriptors: Competing uses, Legal aspects, Water rights, \*Water utilization, Water shortage, \*Water demand, Water law, Water supply, \*Water control, lowa, Water policy, Comparative costs, Comparative benefits, \*Cost-benefit analysis, Cost-benefit ratio, Economic justification, Financial analysis, Legislation, Economic efficiency.

Problems arising from the increasing scarcity of water relative to demands are discussed. The nature of increasing demands for water, a framework for analyzing water problems, objectives of water uses, uncertainties relative to water rights, and elements of remedial action are examined. If demands for water continue to increase at present rates, there may be a crucial scarcity within a short time. Fundamental elements of water problem are conflicts among competing uses, and uncertainties with respect to water rights. It is suggested that economic analyses may reveal the relative value of water in alternative uses. From these studies a priority could be established as to which projects warrant immediate attention. Data on physical relationships should be used in making a proper economic analysis of the value of water projects. Legislation is considered essential to remove uncertainties associated with the ownership and use of water. W68-00228

# A STATE STATUTE TO PROVIDE CONTROLS FOR EQUITABLE DISTRIBUTION OF WATER. Harvard Law School, Cambridge

Harv J Legis, Vol 4, No 3, pp 399-419, June 1967. 21 p, 70 ref, disc.

Descriptors: Surface-groundwater relationships, Beneficial use, Water control, \*Water allocation (Policy), \*Administrative agencies, Water law, \*Legislation, State governments, Model studies, Reasonable use, Riparian rights, Prior appropria-

Identifiers: Constitutional law

A state statute for the administration of water use is proposed and discussed. Advantages of an administrative over a judicial approach in establishing a comprehensive plan for water allocation are set forth. The proposed statute is compared with existing state legislation and with the Model Water Use Act drafted by Michigan Law School. The proposed statute is unique in that all other legislation exempts from regulation domestic uses. This statute instead allows use up to 5000 gallons per day for any use before a permit is required. This figure was chosen to exempt domestic and nondomestic uses too small to be worth the administrative burden. The proposed statute and perhaps one other are the only ones which do not exempt existing uses. Constitutional problems inherent in regulating existing uses are discussed. W68-00235

# FEDERAL WATER RIGHTS LEGISLATION AND THE RESERVED LANDS CONTROVERSY. Georgetown Law Journal, Washington, DC.

Geo L J, Vol 53, No 3, pp 750-791, Spring 1965. 42 p, 221 ref.

Descriptors: \*Reservation doctrine, Desert Land Act, Federal-State water rights, Conflicts, Public rights, \*Federal jurisdiction, Legal aspects, Consumptive use, Withdrawal, Non-navigable waters, Water resources development, Legislation, Unappropriated water, Appropriative rights.

One conflict between state and federal control of water use arises from the power of Congress to control water originating or existing within the boundaries of property belonging to the United States. The conflict is between the state law prior appropriation principle that the first user has a prior right which may be forfeited under certain circumstances, and the reservation doctrine holding that the federal government has title to unappropriated waters in non-navigable streams on reserved federal lands which is not forfeited by non-con-formity with state law. The reserved right extends to consumptive uses, dates from the date of reservation, subordinates all subsequent state-created appropriative rights and reserves a quantity of water 'consistent with the purpose for which the land was reserved.' The cutting off of subsequent rights acquired under state law by the federal reserved right is a possible impediment to water resource development by non-federal sectors. To counter this, Congress should establish machinery to determine the reasonableness and extent of federal needs on reserved lands and accordingly prescribe limits on federal rights in terms of quantum of water beyond which the respective states could control and administer.

#### A DRINK FROM THE DESERT.

US Water Conservation Laboratory, Phoenix, Ariz. Ray D. Jackson, and C. H. M. van Bavel. USDA Yearbook of Agr, pp 175-177, 1967. 3 p, 3 photo.

Descriptors: \*Potable water, \*Solar stills, \*Water sources, Soil moisture, \*Deserts, Plastics, Films, Desert plants, Cacti, Arid lands, Beaches, Sands, Equipment. Identifiers: \*Survival.

A new device called a 'survival still' has been developed that enables people to get a drink of water from the desert soil and plants. The still, consisting of a plastic film about 6 feet square and a plastic drinking tube and a small container, will produce about 2 pints of water during the day and about 1 pint at night. The dryness of the soil, availability of plant materials, exposure to sunlight and ease of digging a pit 3 feet across and 2 feet deep are considered when deciding where to locate the still. This modest but dependable source of water could prevent many tragedies. W68-00262

#### BECOME MORE WATER WISE. PART I -- THE ANIMALS' NEEDS,

South Australia Department of Agriculture, Adelaide

D. W. Russell.

J Agr South Australia, Vol 70, No 11, pp 380-384, June 1967. 5 p, 1 fig, 3 photo.

Descriptors: Water sources, Water quality, Water tanks, Stock water, Evaporation, Water loss, Water supply, Water storage, Storage, Sheep, Cattle, Ruminants, Feeds, Hay, Alfalfa, Nutrients. Identifiers: Australia, Saltbush.

The type of livestock together with the geographical location of the range, temperature, condition of the livestock, animal maturity, types of feed, water quality and the position of water points should be taken into consideration when determining the best way of watering livestock to give the highest return for the lowest cost. Cattle use water 2 1/2 times the rate of the same body weight of sheep; water needs depend on feed, and clean water with low mineral content is essential. W68-00286

## 6E. Water Law and Institutions

WATER LAW ATLAS; A WATER LAW

PRIMER, 1968, Department of the Interior, Office of the Solicitor. Thomas A. Garrity, Jr., and Elmer T. Nitzschke, Jr.

N Mex Bur of Mines and Mineral Resources Circ 95, 46 p, 1968. 21 map, 6 ref.

Descriptors: \*Water law, Riparian rights, Legal aspects, Prior appropriation, \*Water allocation (Policy), Legislation, Water utilization, Land tenure, Groundwater, Surface waters, Weather modification, Rainfall, Permits, \*Water rights, Preferences (Water rights), Statutes, Irrigated land. Reasonable use.

## Field 06-WATER RESOURCES PLANNING

# Group 6E-Water Law and Institutions

Identifiers: \*Common law, \*Atlases, Water problems, Population density, State acts.

An atlas format is used to present a concise, basic explanation of water law as it presently exists in the United States. Twenty-one maps show how the States function under water law doctrines, and how particular problems of water law are solved within the framework of rainfall, topographic situation, population density, irrigated lands, value of products grown, etc. Each map is accompanied by a short discussion of the problem and the solution used by the States. In all States, water law is based on either the riparian or appropriation principle. All States west of the 98th meridian, as well as Mississippi and Florida, recognize the appropriation principle, while the remaining States follow the riparian doctrine exclusively. (6 references) W68-00004

#### TITLE TO THE DEEP SEABED: PROSPECTS FOR THE FUTURE.

Harvard International Law Club, Cambridge, Mass. Robert A. Creamer.

Harv Int'l L Rev, Vol 9, No 2, pp 205-231, Spring 1968. 27 p, 116 ref.

Descriptors: Oceans, \*Continental shelf, Continental slope, \*Ownership of beds, \*Deep water, International waters, Law of the sea, \*United Nations, Governments, International commissions, \*International law, Long-term planning, Economic feasi-bility, \*Beds, Legal aspects, Mining, Political aspects.

Identifiers: International conventions, \*Truman Proclamation.

International interest in the ocean floor first developed in 1945 with the Truman Proclamation, claiming for United States control the natural resources of the seabed and subsoil of the continental shelf contiguous to the United States. This stimulated both national and international action, the latter culminating in the 1958 Geneva Convention on the Continental Shelf, which defined the outer limits of coastal control in terms of exploitability. This definition is capable of being applied to mid-ocean regions, but this was probably not the intention of the Convention: the legal status of the deep ocean floor is thus governed by 'customary' international law. This allows exclusive national claims to the deep seabed beyond the continental shelf made on the basis of occupation either through military installations or mineral exploitation. But this aspect of 'customary' international law may permit a 'colonial free-for-all;' and this brings out the need for international control of the deep scabed. This could be accomplished through United Nations ownership. The ramifications and problems of such ownership is discussed, and the United States is urged to take an active role in accomplishing it. W68-00104

# DEVELOPING THE RESOURCES OF THE SEA-SECURITY OF INVESTMENT,

American Bar Association Section of Natural Resources Law, Chicago, Ill.

Seymour S. Bernfeld.

Natural Resources Lawyer, Vol 1, No 1, pp 82-90, Jan 1968. 9 p, 32 ref.

Descriptors: \*Continental shelf, \*Deep water, International waters, Law of the sea, Oceans, \*Exploitation, Long-term planning, Project planning, International commissions, \*United Nations, International commissions, \*United Nations, Water law, \*International law, Beds, \*Ownership of beds, Political constraints, Exploration, Subsurface investigations, Beds. Identifiers: \*Truman Proclamation of 1945.

Inquiry is made into the adequacy of the legal climate provided by existing law of the sea to warrant financial commitments necessary for undersea mineral resources development. The Geneva Convention of 1958 provided the first formal international recognition of the right of nations to mine beds of their territorial seas, although the Truman proclamation was a unilateral assertion of this right. The rule for determining national control over seabed exploitation is governed by the continental shelf concept. However, the Convention defined the shelf alternatively as seabed adjacent to the coast to the depth of 200 meters or superjacent seabed to depths admitting of exploitation of natural resources. The difficulty with this definition lies in the nebulous nature of 'exploitation' and the fact that it provides no legal security for exploration investments. A basic requirement--creation of possessary rights and sanctions for enforcing them during the exploration period--is missing beyond the 200 meter mark. Three alternative solutions to the problem are posed: (1) United Nations disposition of sea beds to bidder nations; (2) United Nations apportionment of sea beds among member nations; (3) opening the seas and their subsoils for claim staking. Author suggests adoption of the second al-W68-00107

#### THE CONTENTS OF DAVIE JONES' LOCKER--A PROPOSED REGIME FOR THE SEABED AND SUBSOIL,

Rutgers Law Review, New Brunswick, New Jersey.

L. F. E. Goldie. Rutgers L R, Vol 22, No 1, pp 1-66, Fall, 1967. 67 p, 138 ref, 2 append.

Descriptors: \*Continental shelf, \*Continental slope, International waters, Law of the sea, \*Exploitation, \*Resource allocation, Public rights, Ownership of beds, \*International commission, \*Political aspects, Social function, Deep water, International law.

Identifiers: Exploitability test, 200 meter isobath.

The 200 meter isobath ignores the geographic realities of the sharp downward break in the seabed at the ocean rim, but has the advantage of certainty. The exploitability test is ambiguous, may lead to national incorporation of the seabed underlying international waters, and may result in political conflict as nations race to claim the ocean floor. Different resources require different techniques for exploitation. States should acquire rights in the seabed only for resources which are exploitable at that time. The exploitability test should be abandoned. Three alternatives have been proposed: (1) division of the sea floor among coastal nations; (2) application of the laws of the nation whose expedition occupies the particular area of the seabed; (3) establishment of an international leasing agency. The first proposal yields unjust and bizarre results. The second could result in a breakdown in laws insuring proper methods of exploitation by encouraging large corporations to register under the flag of nations with permissive exploitation laws. An international leasing agency authorized to grant ex-ploitation rights, while preserving the right of free scientific research, should be created. The author discusses three blueprints for such an agency and offers his own model. W68-00108

# EMINENT DOMAIN - COMPENSATION FOR SUBSTANTIAL IMPAIRMENT OF RIPARIAN OWNER'S RIGHT OF ACCESS DENIED. Vanderbilt University School of Law, Nashville.

Vand L Rev, Vol 21, No 2, pp 277-282, Mar 1968. 6 p, 28 ref.

Descriptors: \*Eminent domain, Federal government, Public rights, \*Riparian land, \*Riparian rights, Riparian waters, Navigable waters, State governments, \*Water law, \*California. Identifiers: \*Public policy, \*Dominant servitude.

A majority of jurisdictions hold that a riparian owner has a right of access to the channel of the watercourse on which the land is situated. However, this right is not necessarily a property right for which compensation is required, as in eminent domain proceedings, when damaged or taken for

public use. The federal government may infringe upon this right in navigable waters, pursuant to its power over navigation, without being required to give compensation for a taking of private property. But unlike the federal government, state governments are not limited to power over navigation as the basis for exercising the right to impair private access for public purposes. Some state recognize no private rights as superior to the state's right to use navigable waters for any public purpose; but the majority limit the scope of the 'servitude' to public actions connected with the improvement of navigation. All jurisdictions hold that the right of access is only to the channel fronting the owner's land; and no rpivate redress can be had for obstruction by the state of passage upstream of downstream. The rest of the article comments on an application of these principles in a California W68-00121

#### FREESTATE INDUS DEV CO V T AND H, INC. West Publishing Co., St Paul, Minn.

209 So 2d 568 (2d Cir Ct App La 1968).

Descriptors: Surface drainage, \*Surface runoff, \*Drainage water, Civil law, \*Water law, Water \*Drainage water, Civil law, \*Water lawrights, \*Louisiana, Watercourses (Legal).

The plaintiff, a lower landowner, brought an action against the defendants, upper landowners, seeking to enjoin them from draining water onto the plain-tiff's adjacent tract of land. This was coupled with an alternative plea for monetary damages. The court found that an old riverbed abuting the plaintiff's land into which the defendants' land drained caused the plaintiff's land to owe a servitude of natural drainage to the land of the defendants. The court also held that the Louisiana Civil Code is to be literally construed in favor of the estate to which the servitude is due; and therefore the defendant could cut ditches or use other means to concentrate the speed and flow of the drainage water so long as it did not increase the amount. But since the owner of a servitude of drainage may not go upon the servant estate and do acts without the consent of the owner, there was an illegal trespass on the plaintiff's property by the defendants' drainage system for which nominal damages are due. W68-00126

#### WAPPLER V BRAUGHT. West Publishing Co, St Paul, Minn.

209 So 2d 603 (2d Cir Ct App La 1968).

Descriptors: \*Surface drainage, \*Surface runoff, Drainage water, Civil law, \*Water law, Water rights, \*Louisiana.

The defendant constructed a wall with a six inch drain between his property and the plaintiff's. The plaintiff brought an action for mandatory injunctive relief requiring removal of the obstruction preventing water from flowing from the plaintiff's upper estate over the defendant's lower estate. The Louisiana Civil Code states that the lower owner is under a servitude to the upper owner to receive waters running naturally from the upper estate. The lower owner cannot raise any obstruction to prevent the running of the water, and the upper owner cannot render the natural servitude of the lower owner more burdensome. The court held that the responsibility for the free flow of water is primarily on the defendant. However, the defendant was only required to take reasonable measures necessary to give the plaintiff a full right of servitude of drainage. The court thought installation of a larger pipe might be sufficient.

W68-00133

# THE RIGHT OF ACCESS TO NAVIGABLE WATERS BY RIPARIAN LAND OWNERS. Willamette Univ. College of Law, Salem, Oregon.

## Water Law and Institutions—Group 6E

Willamette L J, Vol 3, No 1, pp 67-71, Spring 1964. 5 p, 32 ref.

Descriptors: \*Riparian rights, Navigable waters, Tidal waters, Relative rights, \*Riparian land, \*Access routes ownership of beds, Riparian waters, Water law, Non-navigable waters, High water mark, Low water mark, Governments. Identifiers: \*Access, \*Riparian owners, \*Right of

dentifiers: \*Access, \*Riparian owners, \*Right of access.

General and Oregon law on the riparian right of access to navigable waters is examined. Other rights of riparian owners are mentioned. The right of access extends only to the high-water mark. Navigable means water subject to the ebb and flow of tide, or water which is in fact navigable. At common law the crown owned bottoms of all navigable water. If water was non-navigable, adjacent owners held to the center of the stream or lake. In the United States this rule of ownership is the same. Upon admission to the union, title to tidelands (lands between the high- and low-water marks) and the beds of navigable streams vested in the states, subject to the Federal right to regulate interstate commerce and the public right of navigation. Title to non-navigable bottoms remained in the United States. Hence a state can convey tidelands and make its grantee a riparian owner to the exclusion of a previous grantee from the United States. At common law, public watercourses were part of the public domain, not subject to private rights. The United States majority rule states that the private riparian right of access is a property right which can be protected by legal action. W68-00135

IN RE RIVER QUEEN. West Publishing Co, St Paul, Minnesota.

275 F Supp 403 (DCWD Ark 1967).

Descriptors: \*Admiralty, \*Federal jurisdiction, Navigation, \*Non-navigable waters, Ownership of beds, Boating, \*Dams, \*Reservoir, Condemnation, Eminent domain, Federal Government, Riparian land, Accidents, Legal aspects, Lakes, Reservoir sites, Boats, Boundaries (Property).

This is a proceeding in admiralty on a petition to limit liability. A fire occurred on petitioners' thirtyeight foot boat while it was moored to a dock on Beaver Lake, damaging other vessels and shore structures. The court held that Beaver Lake was not a navigable stream for purposes of Federal admiralty jurisdiction and dismissed the petition. Beaver Lake is a reservoir created by the construc-tion of Beaver Dam on the White River. Navigabili-ty is a question of fact. The court looked to the physical characteristics and use made of the White River prior to construction of the dam to determine navigability. In holding Beaver Lake non-navigable the court considered the following: (1) Prior to construction of the dam the White River was a small stream usable only by small fishing boats. (2) No evidence of actual or potential use for commercial purposes prior to construction of the dam was introduced. (3) In Arkansas the riparian owner on a navigable stream owns only to the high-water mark, yet the United States when acquiring land for the reservoir by eminent domain took title to the center of the stream. W68-00139

STATE EX REL WILCOX V TOL, INC. West Publishing Co, St Paul, Minn.

206 So 2d 69 (4th DCA Fla 1968).

Descriptors: Easements, \*Bridge construction, Navigation, Water law, \*Florida.

Appellant property owners abutting waterways brought an action for alleged public nuisance against private corporation constructing a fixed span bridge across Mosquito Control Canal. The bridge was necessary to grant access to sewage

treatment plant. The bridge would materially cutoff most marine traffic to the north although the
ocean would remain accessible to the south. Court
refused to uphold allegation of nuisance. The county commission had the authority to grant construction rights by virtue of the police power. A public
easement may be imposed on land already subject
to an easement where the latter is for a paramount
public purpose which cannot be effected in any
other practical way or where the latter easement
will not materially interfere with the operation of
the older easement.
W68-00140

LAW OF THE LAKES, State Bar of Michigan, Lansing. Nicholas V. Olds. Mich State B J, Vol 44, No 2, pp 14-20, Feb 1965. 7 p, 16 ref.

Descriptors: \*Great Lakes, International Joint Commission, Treaties, International law, \*International waters, Federal government, Interstate compacts.

The legal framework governing the rights, duties, and obligations of the people using the waters of the Great Lakes Basin may be divided into four categories: treaties and executive agreements; accepted principles of international law; federal and state laws; and interstate compacts and reciprocal agreements. Early treaties and agreements delineated the boundary between the United States and Canada, dealt with navigation of boundary waters, and established the Great Lakes and their connecting waterways as free common highways of commerce. The principles of international law outlaw unilateral change in the regime of international waters and envisage that no nation shall undertake such a change without prior and reasonable consultation with its neighbor. Both federal and state laws are applicable to the Great Lakes, such as the federal right to control commerce and the right of the states to control pollution and to the ownership of beds. An interstate compact has been formed by all of the Lake States to study and resolve mutual problems, and reciprocal agreements between Michigan and Ontario have been made concerning traffic problems. W68-00141

STAPLIN V CANAL AUTHORITY. West Publishing Co, St Paul, Minn.

208 So 2d 853 (1st DCA Fla 1968).

Descriptors: \*Eminent domain, Easements, Recreation, \*Florida.

The Canal Authority instituted an action in eminent domain to acquire fee simple title to reservoir and contiguous collar of land. The action was resisted by Staplin on the ground that a perpetual easement would be sufficient. The District Court of Appeal upheld the power of the Canal Authority to initiate eminent domain proceedings. Ancillary to the power of eminent domain is a broad discretion as to the property to be acquired. This discretion will not be overturned in the absence of fraud, bad faith, or gross abuse. However, the Canal Authority will not be permitted to take a greater interest in the property than is necessary. The Court upheld a finding below that a fee simple was necessary and recreational purposes incidental.

DELAWARE EX REL BUCKSON V PENNSYL-VANIA RR CO.

West Publishing Co, St Paul, Minn.

237 A 2d 579 (Del 1967).

Descriptors: \*Delaware, \*Pennsylvania, \*Landfills, Judicial decisions, Riparian land, \*Riparian rights, State governments, Low water mark, Watercourses (Legal).

The case involved a controversy over title and related rights to certain forshore, a strip of soil on the Delaware River between the high and low water marks. The defendant Pennsylvania Railroad Co., a riparian owner, desired to artificially fill the foreshore. The State contended that its consent was required for the filling. The court first held that the State has the power to legislate with respect to the waters in the foreshore other than for the purposes of fishing and navigation. However, the court also held that the State has not exercised this power in a way that precluded the defendant from building a dike and backfilling behind it without State consent. An examination of relevant statutes showed no exercise of the power. As to the common law principle that a riparian owner holding to the low water mark may not artificially fill to that point, the court stated that the reasons for the rule are fishing, navigation, and improvement of the stream. Since improvement of the stream refers only to its use for navigational purposes and fishing and navigation cannot be urged by the State, State consent is unnecessary upon the facts of this case. W68-00144

TRUSTEES OF THE INTERNAL IMPROVE-MENT FUND V SUTTON. West Publishing Co, St Paul, Minn.

206 So 2d 272 (3d DCA Fla 1968).

Descriptors: \*Accretion (Legal aspects), Boundaries (Property), Judicial decisions, \*Riparian land, Riparian rights, \*Florida, Low water mark.

The case involved a suit to quiet title to property as originally surveyed, together with a large abutting area, between a government traverse on the boundary of the plaintiff Sutton's undisputed property and the line of mean low water on the edge of the bay. The lower court entered a final summary decree vesting title to the disputed property in the plaintiff. The court in the instant case held the decree of the lower court was improper, since issues were presented as to whether the property claimed by the plaintiff was of such a character as to render it susceptible of addition by accretion and as to whether any increase of riparian land became an addition to State property or land owned by the plaintiff. The court stated that Florida follows the common law rule which vests title to soil formed along navigable waters by accretion in owners of abutting land. But in order to acquire land by accretion, there must be natural and actual continuity of accretion to the land of the riparian owners. This was at issue in the suit, and the final summary decree must therefore be set aside. W68-00145

UNITED STATES V LOUISIANA. 88 S Ct 367 (1967).

Descriptors: \*Submerged Lands Act, Boundary disputes, \*State jurisdiction, Federal jurisdiction, Judicial decisions, Ownership of beds, Water law, \*Texas, Florida, Louisiana, Gulf of Mexico.

The Submerged Lands Act, 43 U. S. C. 1301-15 (1964), makes two separate types of grants of sub-merged land to the States. The first allows each coastal State to claim a seaward boundary out to a line three geographical miles from its coast line. The second allows States bordering on the Gulf of Mexico under certain conditions to claim their historical boundary as it existed at the time the State became a member of the Union. The maximum limitation is that no State may claim more than three marine leagues. Texas claimed that for the purpose of the three league grant its boundary extended from artificial jetties constructed by it into the Gulf of Mexico. In an opinion delivered by Mr. Justice Black, the Court held that according to the clear wording of the statute Congress intended that the three league claim be measured to such boundary as it existed at the time the State became a member of the Union. Therefore, Texas is limited in its claim to fixed historical boundaries, which, upon the facts of the case, did not include the jet-

# Field 06—WATER RESOURCES PLANNING

# Group 6E—Water Law and Institutions

ties in question. Mr. Justice Stewart concurred in the result, and Mr. Justice Harlan dissented. W68-00146

THOMAS V BOARD OF COMM'RS. West Publishing Co., St. Paul, Minn.

208 So 2d 163 (La 1968).

Descriptors: Louisiana, \*Eminent domain, Legal aspects, Judicial decisions, Riparian rights, \*Levees.

Before land not bordering on a navigable river is held subject to public servitude for levee purposes, it must first be shown that the tract was riparian property when separated from the public domain, i.e., that the servitude in favor of the public for levees was imposed by French and Spanish land grants which separated the land from the public domain. If this is shown, then the servitude includes not only property which adjoins the water's edge, but all that is within the range of reasonable necessities of the situation and produced by the forces of nature unaided by artificial causes.

W68-00149

UNITED STATES V 28899.17 ACRES OF LAND, MORE OR LESS, IN BREVARD COUNTY, STATE OF FLORIDA.

West Publishing Company, St. Paul, Minn.

269 F Supp 903 (DEMD Fla 1967).

Descriptors: \*Condemnation, \*Compensation, High-water mark, \*Ownership of beds, United States, Boundaries (Property), \*Eminent domain, State government, Federal Government, Judicial decisions, Legislation, Riparian land, \*Condemnation value, Payment, Navigable waters. Identifiers: \*Swamplands Act of 1850, \*Sovereignty lands, \*Patents (Land).

This was a condemnation proceeding by the United States wherein the defendants sought additional compensation for submerged lands under a navigable waterbody. Defendants claimed title through a patent to the State of Florida by United States under the 1850 Swamplands Act. This provided that all swamp and overflowed lands within the state which had not previously been conveyed out would pass by patent to the states. By virtue of its admission into the union, Florida had taken title to all lands under navigable waters and all tidelands, hence the United States had no title to convey at the time of the purported patent. The State's legal right to convey swamp and overflow lands which had been granted under the 1850 Act was conferred by the State on the Trustees of the Internal Improvement Fund in 1855, and did not include the power to convey sovereignty lands. Since the State lacked authority, the conveyance by the Trustees was ineffectual. The deeds by the Trustees intended to convey only what they had legal right to convey. The deeds refer to riparian rights, indicating a conveyance only to the high-water mark. The defendants' plea for additional compensation was denied W68-00151

BRYANT V LOVETT. West Publishing Co., St. Paul, Minn.

201 So 2d 720 (Fla 1967).

Descriptors: \*Ownership of beds, \*Regulation, \*Oysters, Shellfish, Commercial shellfish, Public lands, State governments, \*Beds under water. Identifiers: \*Sovereignty lands, \*Trust doctrine, Public policy.

This was action to enjoin enforcement of a state statute. The plaintiff's predecessors received grants of exclusive rights to cultivate oysters under an 1881 act of the Florida legislature authorizing counties to grant such rights in submerged lands

within the county. In 1961 the legislature passed a law providing for forfieture of the grants unless certain requirements, including payment of rent and registration, were met. Plaintiffs seek to enjoin enforcement of this statute on the grounds that it deprives them of property without due process of law or just compensation. The court held the original grants ineffectual to convey any interest in the submerged lands. These grants were without consideration and with virtually no restrictions on the grantee. The state was therefore 'taking' no property when it placed additional requirements on grants by the 1961 act. The court noted the public policy of the state favoring protection of sovereignty lands. Tidal and submerged lands and uses thereof are held in trust for all the people of the state. The most these grants could give plaintiffs was color of authority to enter on the lands and plaintiffs must prove actual and continuous use to establish a legal right in the lands. W68-00152

SARASOTA COUNTY ANGLERS CLUB, INC V

West Publishing Co., St. Paul, Minn.

193 So 2d 691 (1st D C A Fla 1967).

Descriptors: \*Beds, Beds under water, \*Administrative decisions, \*Florida, \*Judicial decisions, Legislation, Water law.
Identifiers: Public interest.

The case involves an appeal by plaintiff Sarasota County Anglers Club, Inc. from an order dismissing the complaint. The complaint alleged that defendants Arvida and CC Shores, with the consent and approval of the defendants Town of Longboat Key and Trustees of the Internal Improvement Fund, propose to fill submerged land off Longboat Key, to the detriment of the use thereof by the plaintiffs and others similarly situated. The court upheld the dismissal on the ground that plaintiffs are in no position to maintain this action. However, the case's importance warranted discussion of the merits. Title to public bottoms is vested in the State and managed by the Trustees of the Internal Improvement Fund as a public trust to be held for the benefit of all the people. But this trust does not require all public bottoms to be kept in their original state. Legislation gives the Trustees responsibility for determining when the public interest demands alterations, such as docks and filling. Since there is no allegation that the statute under which the defendants operated is invalid, or that defendants acted in bad faith or exceeded their statutory powers, the case fails on the merits. W68-00155

MORGAN V CANAVERAL PORT AUTHORITY. West Publishing Co., St. Paul, Minn.

202 So 2d 884 (4th D C A FLA 1967).

Descriptors: \*Beds under water, Ownership of beds, \*Administrative agencies, Judicial decisions, \*Florida, Legal aspects, \*Riparian land.

Plaintiff Morgan brought an action against defendant Canaveral Port Authority to void a deed from the Trustees of the Internal Improvement Fund conveying to the defendants submerged and sovereign lands in the Banana River. The submerged lands in dispute, purchased in 1948, abut uplands on one side subsequently leased or purchased by the plaintiff. The court held that the defendant was under no statutory obligation to disclose to the trustees that it was not a riparian owner. The court also held that the issues of inequitable distribution of submerged lands and violation of a trust requiring submerged lands and violation of a trust requiring submerged lands to be held and protected for the benefit of riparian owners and the public are settled by FLA. STAT. ch. 253 (1965). This chapter places title to such lands in the trustees, authorizes their conveyance, and provides for objection proceedings. A riparian owner has no preferential privilege or specific

rights to the purchase of sovereignty lands under the statute. In addition, in 1951 all conveyances of sovereignty lands by the trustees were ratified by the legislature. Thus, since the application and conveyance complied with statutory requirements, the judgment for the defendants was affirmed. W68-00156

O'NEILL V STATE HIGHWAY DEPARTMENT. West Publishing Co., St. Paul, Minn.

50 N J 307, 235 A 2d I (1967).

Descriptors: \*Tidal waters, \*High water mark, Tidal marshes, Sea level, Intertidal areas, Condemnation, Natural flow, Doctrine, \*Boundaries (Property), \*Ownership of beds, \*Obstruction to flow.

Identifiers: Mean high tide.

The issue presented was whether the state or private party owned certain tidelands. The court held that the state owns tidelands up to the high water mark. This is the line of the 'mean high tide, which should be determined, if possible, on the basis of all high tides over the last 18.6 years. The fact that land above the mean high tide level is periodically covered by high tide does not prove it tideland owned by the state. Nor is interior land below that level, not naturally reached by mean high tide, owned by the state. The state cannot acquire interior land by artificial works such as ditching which allow the tide to reach lands ordinarily beyond it, nor can the riparian owner artificially exclude the tide. The burden of proof falls upon the asserter, whether it be the state or riparian owner, to prove that artificial measures changed the tideland status of the land. Lay observations of tidal flow upon the land could not prevail against unequivocal evidence that the undisturbed land was above mean high tide level, but could not be rejected absent certain proof of property status before artificial changes. W68-00157

### HILL V MCDUFFIE.

196 So 2d 790 (1st D C A Fla 1967).

Descriptors: \*Dikes, \*Florida, Judicial decisions, Riparian land, \*Riparian rights, Water law, \*Drainage wells, High water mark.

Plaintiffs, riparian owners on a non-navigable lake, brought an action to enjoin defendants' maintenance of a dike and dry wells on land bordering the lake. The lower court held for the plaintiffs, and the defendants appealed. The court in the instant case found that the plaintiffs failed to prove that defendant Hill's dike was within the ordinary highwater mark of the lake. Although the lake at times covered Hill's lands inland from the dike, the court stated that the plaintiffs had no unrestricted right to use this property. Since these lands were dry for a 'goodly portion' of the past 15 years, the rule that one owner of a part of a non-navigable lake cannot cut off other owners from using the entire lake would not apply here. In addition, riparian owners in the defendants' position have the right to construct dikes and dry wells to protect their property, if this can be done so as not to damage property of others, prevent access to lake waters by other riparian owners, or drain the lake below the normal highwater mark. The order of the lower court being overbroad, the case was reversed and remanded W68-00162

TRUSTEES OF THE INTERNAL IMPROVE-MENT FUND V SUTTON. 206 So 2d 272 (DCA 3rd Fla 1968).

Descriptors: \*Accretion (Legal aspects), Low water mark, Riparian land, Boundary disputes, Florida.

## Water Law and Institutions—Group 6E

The appellee Sutton was awarded 88.94 acres of alluvion by summary decree. Appellee petitioned in 1960 to quiet title to certain property including the alluvion area. The primary question on appeal was whether there had in fact been accretion. The Court held that natural and actual continuity of accretion was necessary to the riparian owner's land. There must be an actual affixing of accretions. Florida follows the common law rule which vests the title to the soil formed along navigable waters by accretion in the owners of abutting lands. W68-00190

# UNITED STATES GYPSUM CO V GRIEF BROS COOPERAGE CORP. 389 F 2d 252 (8th Cir 1968).

Descriptors: Arkansas, \*Accretion (Legal aspects), Judicial decisions, Riparian rights, Islands, Navigable waters, Ownership of beds

Under Arkansas law, when a land formation begins with a bar or an island detached and away from the shore, and by a gradual filling in of soil or by gradual recession of the water the space between the bar or island and mainland is joined together, it is not an accretion to the mainland and does not thereby become the property of the owner of the riparian tract. A reformation of submerged lands not within the original boundaries of the riparian tract would, if formed as an island in a navigable stream, belong to the state of Arkansas. W68-00194

# WARD SAND AND MATERIALS CO V PALMER.

237 A 2d 619 (NJ, 1968).

Descriptors: \*New Jersey, \*Tidal marshes, \*Land reclamation, Wetlands, Judicial decisions, Legal aspects, \*Land tenure.

Generally, title to lands flooded at mean high tide is vested in the state of New Jersey. By state common law, and subsequently by statute until it was repealed, the owner of the upland at the high water mark had the privilege or license of reclaiming tideflowed lands adjacent to such holdings to the low water mark. When this privilege was exercised, the state became divested of and the upland owner became vested with absolute title to the lands so reclaimed. The exclusion of the tide was a condition for the vesting of title between the high and low water mark. If the reclaimed lands become again tideflowed, title to the lands does not immediately re-vest in the state. The title and right to possession remain vested in the private owner for a reasonable period of time. A reasonable period is a time sufficient to accord him the opportunity to again exclude the tide. W68-00198

# UNITED STATES V HUGHES. 278 F Supp 733 (ED Tenn, 1967).

Descriptors: \*Easements, Legal aspects, Judicial decisions, Water level fluctuations, Tennessee Valley Authority Project, Federal government. Identifiers: Flowage casements.

TVA as owner of a flowage easement on defendant's land seeks removal of trailers placed by defendant on land subject to easement. The rights of TVA in land upon which it has a flowage easement are measured by the purpose of the easement, which is not a conveyance in fee of land, but only of rights and privileges granted by the easement. Defendant has all rights and benefits of ownership of servient estate consistent with the easement, and right to use the land remains in him as long as it does not conflict with the purpose and character of the easement. A grant of water easements carries with it by implication, as secondary or subsidiary easements, everything that is beneficially necessary or incident to the grant, whether mentioned or not. The respective rights of dominant and servient owners must be so used as not to unreasonably interfere with each other. Though the rights of the easement owner are paramount to those of the land-owner, to the extent of the easement, the rights of the two parties are not absolute, but are so limited by each other that there may be a reasonable enjoyment of both the easement and servient estate W68-00201

### COMMONWEALTH HIGHWAYS V ROBBINS. DEPARTMENT

West Publishing Co, St Paul, Minn.

421 SW 2d 820 (Ky Ct App 1967).

Descriptors: Culverts, \*Highway effects, Surface runoff, \*Surface drainage, Condemnation, Ditches, State governments, Kentucky, \*Natural flow doctrine, Damages.

The action was to recover damages for wrongfully causing water to collect on plaintiff's land. Evidence showed that a highway constructed at the rear of the plaintiff's property had caused water to collect on the property, since the only provision for water was a ditch along the highway that turned into a culvert which was constructed with the highway and that the culvert opened onto plaintiff's land. Plaintiff was not estopped by the condemnation deed which recited that \$600 had been given in consideration for land taken and 'for all other damages both present and prospective', since it could not have been foreseen by landowner that the condemnation of a strip of land at the rear of the lot would result in constant inundation of the remainder of the lot. The court held that where surface water is unreasonably diverted from its natural course of drainage and is cast upon land onto which that surface water had not previously flowed, the person causing the diversion is liable for resulting damage. W68-00206

#### **ELLIOT V NORDLOF.** West Publishing Co, St Paul, Minn.

83 111 App 2d 279, 227 NE 2d 547 (1967).

Descriptors: \*Highway effects, Local governments, Civil Law, \*Diversion, Surface runoff, Illinois, Damages, Construction, \*Natural flow doctrine, Land development.

Plaintiffs sought injunction and damages against the City, a land developer, and homeowners for diversion of surface water. They alleged that construction of a street by the land developer provided a drainage way for collecting surface waters that normally did not discharge or flow onto plaintiffs' recently being they are defined against the land. property. Injunction was denied against the land developer and the homeowners since recordation of the land developer's plat gave sole control of the street to the City. Denial of injunction against the City was not appealed. Damages against the homeowners for utilization of the street drains was dismissed for failure to state a cause of action. Following the Civil Law Rule that states basically that waters must be allowed to flow naturally from dominant tracts to adjoining servient tracts, the Court found that construction of the street resulted in diversion and held both the land developer and the City liable for damages. W68-00207

#### DEVAZIER GRAVEL, INC V BUSBY. West Publishing Co, St Paul, Minn.

414 SW 853 (Ark 1967).

Descriptors: Drainage, Minc drainage, Ditches, Drainage systems, \*Mine wastes, Mine water, Mining, \*Damages, Gravels, Cultivated lands, \*Remedies, Waste water disposal, Civil law, Water law, Judicial decisions, \*Overflow. Identifiers: Drainage ditches, Farm drainage.

Defendant's mining activities caused large quanti-ties of sand and clay to be deposited in plaintiff's drainage ditches. In wet weather the drainage ditches overflowed, causing damage to plaintiff's adjacent farmlands. Defendant had made some efforts, all ineffective, to clean out the drainage ditches. A real-estate dealer testified at the trial that the value of plaintiff's property had been sub-stantially reduced due to the deposits. Removal of the deposits would be difficult and expensive. Defendant offered no justification for its course of action other than self-interest. The Supreme Court of Arkansas held that the evidence was sufficient to support an injunction permanently enjoining defendant from allowing its waste to reach plaintiff's drainage ditches, and an award of \$12,000 for pecuniary injuries already suffered. Only a permanent injunction, the court said, could afford plaintiff the protection that he was entitled to. W68-00209

# CARAVAN AND MANNING, INC V FREED-

West Publishing Co, St Paul, Minn.

232 NE 2d 680 (Mass 1968).

Descriptors: \*Remedies, Rainfall disposition, Runoff, \*Surface runoff, Storm runoff, Surface waters, Civil law, Judicial decisions, Water law, Damages, Embankments, \*Base flow, Groundwater, Barriers.
Identifiers: Water accumulation.

The plaintiff was leasing land from defendant. Defendant maintained an embankment for storing gravel and debris on property adjacent to the land leased to plaintiff. The embankment barred the natural flow of ground water. During a period of heavy rainfall water collected at the embankment and flooded plaintiff's premises. The Supreme Judicial Court of Marian Control of the Court of Marian Court o cial Court of Massachusetts held that a landowner may interfere with the natural flow of surface water by appropriation of his land to any lawful use. In plaintiff's action for damages caused by flooding it made no difference that defendant's appropriation resulted in the flow and gathering of water on premises leased to plaintiff. Recovery could have been allowed if there had been a showing of artificial channelling or some augmentation of the natural flow of water. W68-00210

#### CAPUNE V ROBBINS. West Publishing Co, St Paul, Minn.

160 SE 2d 881 (N C 1968).

Descriptors: Riparian rights, \*Navigation, Piers, Navigable waters, Ownership of beds.

Defendant's ownership of a pier and adjacent beach allows him to prohibit use thereof by others. However, it does not follow that he could lawfully prohibit use of ocean water beneath the pier as a means of passage by water craft making no contact with the pier. Without the grant of an easement in submerged land defendant owner of pier depended solely on his status as riparian or littoral owner for his rights. Without specific legislation, a littoral proprietor and a riparian owner have a qualified property right in the water frontage.

W68-00212

# SUNSET ISLANDS NO. 3 AND NO. 4 PROPERTY OWNERS, INC V CITY OF MIAMI BEACH. West Publishing Co, St Paul, Minn.

210 So 2d 275 (3rd DCA Fla 1968).

Descriptors: Bulkhead line, \*Legal aspects, \*Florida, \*Legislation.

This case arose on a petition to quash an ordinance of the City of Miami Beach, establishing a bulkhead line. The sole question on appeal was whether the petition was timely filed. Under Florida Statute

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253.122 (6) (1967), property owners may appeal for review of an establishment of a bulkhead line by a board of county commissioners, a municipal body, or the trustees of the internal improvement fund. The filing must be within the time provided in the Florida appelate rules. The court held a decision may appeal the bulkhead establishment prior to approval of the trustees of the internal improvement fund. If a party chooses to appeal, however, it must be timely filed in accord with Florida Appellate Rule 3.2 (b). In this case the appelate's petition was filed after the 60 day period of filing. was filed afte W68-00216

STATE EX REL BUCKSON V PENNSYLVANIA RAILROAD COMPANY. West Publishing Co, St Paul, Minn.

228 A 2d 587 (Del 1967) 19 p, 1 fig.

Descriptors: Boundary disputes, \*Boundaries (Property), Federal government, State government, Legislation, Riparian land, \*Riparian rights, Navigable rivers, \*Intertidal areas, Delaware River, Surveys, High water mark, Low water mark, Water law, Dikes, Fishing, \*Judicial decisions, \*Water courses (Legal), Patents, Rivers and Harbors Act.

The controversy in this case was over legal title and rights to a certain foreshore or intertidal area along the Delaware River. Title to the foreshore de pended on a tracing of the chain of title to the individual parcels comprising the disputed foreshore. The Court found the property in question owned by the railroad to be riparian land partially on the basis of the original surveys. It was noteworthy that the conveyances evidenced an intent to make the river one boundary. Having found the railroad a riparian owner, the court next considered whether the rights of a riparian owner extended to the low water mark. The Court held the foreshore was owned by the railroad on the basis of its rights as a riparian owner, not from its original patents. Early Delaware decisions extended the riparian owner's rights to the low water mark and the Court agreed that state decisions should be especially weighty in considering titles to real property. Despite the railroad's apparent right to the foreshore, summary judgment was precluded by filling operations which tended to change the low water mark. The Court also held that a federal government declaration of lawfulness as to the construction of a dike was superior to a state claim of interference with naviga-W68-00217

WATERS AND WATERCOURSES-RIPARIAN OWNER OF BOTH SIDES OF NON-NAVIGABLE STREAM HELD ENTITLED TO ENJOIN REPEATED TRESPASS BY FISHING. Virginia Law Review Association, Charlottsville

Va L Rev, Vol 42, No 1, pp 121-122, Jan 1956. 2 p.

Descriptors: \*Navigation, Judicial decisions, \*Ownership of beds, Riparian rights, Riparian owners, Navigable waters, \*Fishing, Recreation, Non-navigable waters.

This is a case comment on Boener v McCallister. 197 Va 169, 89 SE 2d 23 (1955). Complaintant owned both sides of a non-navigable stream. His title preceded the state reservation acts. Complaintant sought to enjoin defendant from repeated trespass by fishing within complaintant's property boundaries. The court granted the injunction, thus protecting the complaintant's exclusive property right to fish in a non-navigable stream on his property. W68-00222

CASTAWAYS MOTEL V SCHUYLER.
State of New York; West Publishing Co., St. Paul.

29 App Div 2d 16, 284 N Y S 2d 900 (1967).

Descriptors: \*River beds, \*Administrative decisions, Administrative agencies, \*Adjudication procedure, Judicial decisions, \*New York, Ownership of beds, Legal aspects.

Pursuant to New York law, petitioner Castaways Motel filed a petition seeking a judgment directing the Commissioner of General Services to deliver to the petitioner certain lands under the waters of the Niagra River. Consent of the New York Power Authority was required for a scale of submerged lands in the Niagra River, the criterion being whether the sale would interfere with the Niagra power project. The Power Authority gave its consent, but attached a condition precedent to the sale that relieved the Power Authority and the State of New York from future liability to the petitioner arising out of control or regulation of the waters of the river. The petitioner rejected the condition precedent and brought the present action. The court affirmed a dismissal of the petition on procedural grounds, but indicated that the condition precedent imposed by the Authority exceeded its statutory powers. W68-00230

WISCONSIN V LAMPING.

State of Wisconsin, West Publishing Co., St. Paul,

36 Wis 2d 328, 153 NW 2d 23 (1967).

Descriptors: \*Riparian land, \*Bogs, Navigable waters, \*Landfills, Judicial decisions, Legislation, Water law, Administrative decisions, \*Wisconsin. Identifiers: \*Floating bogs.

Property owners adjacent to the defendant's lakeshore land filed a complaint with the Wisconsin Public Service Commission, which in turn issued an order requiring the defendant Lamping to remove certain fill material he had placed on a marshy peninsula adjoining his property and extending into the lake. A Wisconsin statute made it unlawful to deposit fill on the bed of navigable water where no bulkhead line was established unless a permit was granted by the commission. Since the lake was navigable and no bulkhead line was established, the substantive issue was whether the peninsula was a floating bog or riparian land. If it was the latter, no permit was required. The decision of the lower court in favor of the defendant was reversed and remanded on evidentiary and procedural grounds, but the supreme court gave attention to a correct legal definition of a floating bog. The court defined it as a mass of grass, weeds and other vegetation, which grows and floats on the surface of water in warm weather, where there is a substantial amount of water between it and the bed. The degree of attachment to the bed is a material factor to be considered W68-00231

COASTAL STATES GAS PRODUCING CO V STATE MINERAL BD West Publishing Co., St. Paul, Minn.

199 So 2d 554 (Ct App La 1967).

Descriptors: \*Louisiana, Ownership of beds, \*Prescriptive rights, State governments, Local governments, \*Navigable waters.

The issue presented was whether a Louisiana prescription statute prohibiting the State from at-tacking its conveyances to private practices after the lapse of six years barred the state from at-tacking an 1885 conveyance, insofar as the conveyance included the bed of a navigable stream. Inasmuch as the deed was signed by a local official, and not the Governor and State Register as provided in the Statute, the statute was held not a bar to attack on the conveyance, since prescription cannot be extended by analogy beyond the strict letter of the law. Inherent sovereignty renders beds of navigable waters not susceptible of private ownership. State conveyances including navigable water bottoms within the area transferred are construed strictly against the grantee. Such beds, owned by the state, are not transferred by such conveyances in absence of strong indicia to the contrary. Mere presence of the navigable water bottom within the area described by the conveyance is insufficient indicia to effectuate alienation of such bottoms by the State. W68-00234

JUST COMPENSATION AND THE NAVIGA-TION POWER, Washington Law Review Association, Seattle.

William J. Powell.

Wash L Rev, Vol 31, No 3, pp 271-286, Autumn 1956. 16 p, 73 ref.

Descriptors: Navigable waters, Federal government, Non-navigable waters, \*Water law, Federal Power Act. Boundaries (Property), \*Condemnation, Judicial decisions, Ownership of beds, \*Riparian land, Riparian rights, \*Compensation, Condemnation value, Property values, Watercourses (Legal), Damsites, High-water mark, Legal aspects, Public rights.

Identifiers: Constitutional law, \*Navigation power, \*Navigation servitude, \*Just compensation.

When the United States appropriates private property pursuant to its extensive navigation powers, determination of just compensation required by the fifth amendment is affected by the concept of navigation servitude. Navigation servitude is described as the federal governments dominant power over beds of navigable streams, including lands below the ordinary high-water mark. When the government exercises this servitude, it is exercising its paramount power in the interest of navigation, rather than taking private property. Thus the proper measure of compensation should be the property's fair market value as subject to the servitude. The United States may therefore appropriate or destroy property located in, above, or below navigable waterways for improvement of navigation without payment of compensation. However, the navigation servitude does not burden riparian lands on non-navigable streams. As to lands riparian to navigable streams, or 'fast lands', compensation must be paid for their taking. Cases indicate that it is unnecessary to consider the value of the riparian character of fast lands in determining the measure of just compensation. The situation of licensees under the Federal Power Act in regard to the navigation servitude is examined. W68-00239

NAVIGABLE STREAMS--TESTS OF NAVIGA-

BILITY,
Tulane Law Review Association, New Orleans. J. Malcolm Duhe, Jr. Tul L Rev, Vol 30, No 2, pp 332-335, Feb 1956. 4 p, disc.

Descriptors: \*Public rights, \*Navigable waters, Navigation, \*Boating, Recreation, Judicial decisions, Streams, Water law. Identifiers: \*Pleasure boating.

An action was instituted to compel removal of a fence constructed by defendants across a stream useful only for pleasure boating. The court found the stream to be navigable and ordered removal of the obstruction. In the United States, water which is navigable in fact is navigable in law. This case is contrary to the general rule that to be navigable, a stream must be useful for commerce. This comment contains a well documented discussion of tests of navigability in the United States. W68-00240

JUDICIAL CRITERIA OF NAVIGABILITY IN

FEDERAL CASES, Wisconsin Univ. Law School, Madison. Francis W. Laurent. Wise L Rev, Vol 1953, No 1, pp 8-37, Jan 1953. 30 p. 125 ref.

# **RESOURCES DATA—Field 07** Network Design-Group 7A

Descriptors: \*Inland waterways, \*Federal jurisdiction, \*Judicial decisions, \*Navigation, Navigable waters, Federal government, Boating, Legal aspects, Admiralty, United States. Identifiers: Navigable in fact.

Federal cases dealing with navigability of inland waters fall into six classes: (1) cases of admiralty and maritime jurisdiction; (2) cases arising under the commerce clause; (3) eases arising under treaties; (4) cases involving citizens of different states; (5) cases arising under statutes affecting territories and new states; (6) cases involving federal land grants. Distinct sets of criteria govern determination of navigability under each of these classes; although all classes depend basically on whether or not the waterway is navigable in fact. Navigable in fact means that the waterway in its natural condition is susceptible to being used as a highway of commerce. In admiralty cases artificial waterways such as canals and drydocks navigable in fact are navigable in law. Under the commerce clause artificially obstructed navigable waterways are considered still navigable in law. In cases between citizens of different states, navigability is determined by the law of the state in which the waterway is located. W68-00245

## 6F. Nonstructural **Alternatives**

STATE REGULATION OF CHANNEL EN-

CROACHMENTS, New Mexico Univ. School of Law, Albuquerque. Edward W. Beuchert.

Natural Resources J, Vol 4, No 3, pp 486-521, Jan 1965. 36 p, 92 ref.

Descriptors: Flood plains, Flood Routing, Flood water, Watercourses (Legal), \*Channels, \*Flooding, Channel improvement, Flood control, Flood protection, State governments, Flood control, Flood Flood plain zoning, \*Floodways, \*Administrative agencies, Permits, \*Regulation, Encroachment, \*Obstruction to flow.

Identifiers: \*Department of Floodways, \*Channel encroachment.

This article deals with state regulation of channel encroachments as a means of minimizing flood damage. Common law private rights regarding encroachments which contribute to flood damage, and early statutory attempts to regulate channel encroachments are examined. Previous statutory regulation proved unsatisfactory on six bases: (1) Many statutes were permissive rather than mandatory (2) Statutory standards lacked clarity (3) The statutes did not provide flexible remedies (4) The public was not properly informed of the statutes requirements (5) Statutes were limited to channel rather than floodway encroachments (6) Some statutes did not provide encroachment lines, but merely prohibited channel obstruction. A Model Floodway Encroachment Act is proposed establishing a State Department of Floodways and basing regulation on a concept of Floodway rather than channel. The act provides definite standards for the establishment floodway encroachment lines, declares artificial obstructions to be a public nuisance unless specifically permitted, provides criminal penalties for violation of the act, establishes a mandatory permit system, gives the Department power to remove obstructions and other incidental powers.

W68-00130

# CONTROLLING WATERFRONT DEVELOP-MENT, Florida Univ Public Administration Clearing Ser-

vice, Gainesville.

Sheldon Plager, and Frank E. Maloney. Studies in Public Administration, No 30, pp 1-39, 1968. 39 p, 112 ref.

Descriptors: \*Shores, Competing uses, Conserva-tion, \*Landfills, \*Florida, \*Water law, Navigable waters, Non-navigable waters, \*Docks, \*Coastal structures, Judicial decisions, Legislation, Ownership of beds, Public rights, Riparian land, \*Riparian rights, Watercourses (Legal), Piers, Bulkhead line, Boundaries (Property). Identifiers: \*Waterfront development.

Florida is witnessing a conflice over waterfront development between conservationists and developers. Historically, waterfront regulation was a matter of the riparian right to wharf into a navigable body of water. The article first examines the development of the common law right to wharf based on ownership of the upland, and then turns to the riparian right to wharf in Florida. In the absence of controlling statute, a riparian owner in Florida has a right to wharf on sovereignty lands in front of his uplands, subject to limitations such as the superior rights of the public as to navigation. However, history, policy, and logic indicate that this right does not extend to filling for non-wharfing purposes. Statutes give a qualified right to fill an waters other than fresh water lakes and streams. Private ownership of submerged bottoms as a source of a right to wharf or fill is examined. The use of the navigability concept as a means of controlling waterfront development is analyzed. Cases and statutes affecting a determination of navigability are discussed, particular attention of navigability are discussed, particular attention being given to FLA. STAT. 271,09 (2) (1967). Conclusions and recommendations are presented. W68-00163

# 6G. Ecologic Impact of Water Development

CONSERVATION RECONSIDERED, Resources for the Future, Washington, DC. John V. Krutilla. American Econ Rev, Vol LVII, No 4, pp 777-786, Sept, 1967. 10 p, 14 ref.

Descriptors: Ecology, Elasticity of supply, Recreation demand. \*Environmental effects, tion demand, \*Environmental effects, Geomorphology, \*Technology. Identifiers: Option demand, Externalities, Substitueffects,

It has recently been argued that advances in technology in the U S have permitted a continuous decline in the prices of natural resources relative to commodities in general. This contradicts the doctrine of increasing natural resource scarcity. Yet the degradation of the physical environment, the pollution of air and water continues. There is an asymmetry in the implications of technological progress for producing industrial and agricultural goods on the one hand, and its implication for providing unspoiled natural environments on the other. If the latter are irreproducible and the demand for them in catering to collective consumption wants to expected to grow - i.e., the marginal trade-off between fabricated and natural amenities will tend increasingly to favor the latter - natural environments become assets of appreciating value. If rational behaviour by heads of households involves a bequest motivation, and rare natural environments are attended by indivisibilities, the market will not achieve an optimal allocation. Providing for these goods must now be the central concern of conservation economics.

IRRIGATION IN SEMI-ARID REGIONS,

W68-00173

C.S.I.R.O., Irrigation Research Laboratory, Griffith, N.S.W., Australia. E. R. Hoare.

Outlook on Agr., Vol 5, No 4, pp 139-143, 1967. 5 p, 6 fig, 2 tab, 17 ref.

Descriptors: Arid climates, Humid climates, Semiarid climates, Crop production, Rainfall dis-tribution, Evaporation, Moisture deficit, Water dis-tribution (Applied), Irrigation efficiency, Com-

parative productivity, Rainfall-runoff relationships, Environmental gradient, Population, Runoff, Ecology, Desalinization, Water requirements, Water sources Identifiers: Aridity

Semi-arid lands having less than 15 inches rainfall and evaporation from a surface of more than 45 inches are considered. Comparisons are made between arid and humid areas, water as a food producer, sources of water from the land and sea, amounts of water needed for various agricultural commodities and human needs. The ability of different countries to supply it peoples with food in respect to the supply of water are discussed. Irrigation of the dry areas of the earth will not necessarily solve the gigantic food production problems which face the world, but because of pleasant living conditions, these dry areas will be more heavily populated in the future. Includes map of arid and semiarid areas and tables showing water requirement for agricultural products and human needs W68-00271

# TWO NEW DAMS AUGMENTING SUDAN'S IRRIGATED FARMLAND,

Foreign Regional Analysis Division, Economic

Research Service. Cline J. Warren.

Foreign Agr, Vol 5, No 26, pp 8-9, June 1967. 2 p, 3 photo.

Descriptors: \*Storage capacity, Irrigation water, Economic impact, Social impact, Hydroelectric power, Multiple-purpose projects, Field crops, Irrigation efficiency, Rural sociology, Area development, Soil-water-plant relationships, Productivity, \*Dams, \*Irrigated land, Arid lands, Benefits. Identifiers: Sudan.

Sudan has recently completed the construction of two new dams which together will triple the country's storage capacity for irrigation water. The increased water supply will make it possible for Sudan to double the present irrigated area of approximately 2 million acres and will permit more intensive and improved practices on current cultivated acreage. With the efficient utilization of the new dame and irrigated acreage. new dams and irrigated acreage, Sudan's presence would be more strongly felt in the international market of farm products. W68-00298

# 07. RESOURCES DATA

# 7A. Network Design

SOIL SALINITY SENSOR OF IMPROVED DESIGN.

U S Salinity Laboratory, Riverside, Calif. L. A. Richards.

Soil Sci Soc Amer Proc, Vol 30, No 3, pp 333-337, May-June 1966. 5 p, 4 fig.

Descriptors: Salt tolerance, Electrical equipment, Soil-water-plant relationships, On-site data collec-Soil-water-plant relationships, On-site data confec-tions, Meausrement, Temperature, Saline water, Saline soils, \*Salinity, \*Irrigation, Leaching, Water quality, Equations, Electrodes, Model studies, Screens, Calibrations, Soil investigations.

Identifiers: U S Salinity Laboratory, Riverside, Calif., \*Sensors.

A soil salinity sensor was developed to reduce the response time and to ensure better soil contact with the sensor. The response time was reduced to about one hour when the platinum screen electrodes were fired in place on opposite faces of a porous ceramic plate. A spring plunger was installed in the sensor to maintain good contact between the sensitive element and the soil. For more precise work, where temperature is a variable, a thermistor was incor-porated in the sensor. The sensitive element was shielded and insulated so the resistance of the element did not depend on external current paths. The calibration of the sensor is discussed with respect to

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different salt solution concentrations and temperature ranges. The operation of the sensor in the areas of irrigation tests and leaching-requirement studies are also discussed. W68-00280

## 7B. Data Acquisition

THE MEASUREMENT OF RIVERFLOW WITH RADIOACTIVE ISOTOPES WITH PARTICU-LAR REFERENCE TO THE METHOD AND TIME OF SAMPLING,

Central Africa Agricultural Research Council. P. R. B. Ward, and P. Wurzel. Bull of Int Ass of Sci Hydrol, Vol 13, No 1, pp 40-48, Feb 1968. 2 fig, 1 plate, 2 tab.

Descriptors: \*Radioisotopes, River flow, Streambeds, \*Tracers, Gold radioisotopes, \*Methodology, Gaging stations, Sampling, Gamma rays, Test procedures, Velocity, Calibrations, Laboratory procedures, velocity, Candiations, Laboratory, tests, Channels, Radioactivity, Flow measurement. Identifiers: \*Total Counts method, Scintillation detectors, \*Chromium 51, Rhodesia (Africa), Health hazard, Scaler, Inhomogeneities.

Methods of riverflow gaging are investigated for streams of 10 to 250 cusecs. Radioactive isotopes are used involving withdrawal of samples from the river for count measurements in situ. The Total Counts method is favored because of its ability to sample large volumes and give reliable results. An extension of the method is offered for conditions of noninfinite channel geometry, using a probe in the stream. This allows in situ gaging of streams as shallow as 2 ft. An empirical process for prediction of tracer passage time from point to point is given, based on a series of measurements in rivers at low flow. Merits of colloidal Gold 198 and Chromium 51 EDTA as tracers are discussed. Colloidal gold is found to be insignificantly adsorbed over a measuring reach of 3,000 ft. Use of the Total Counts method in streamflows of 5,000 cusecs or more requires large tracer amounts; this incurs health hazard problems and expense. Thus, the range of application of the method is limited to flows of less than 5,000 cusecs. W68-00008

# APPLICATION OF AERIAL PHOTOGRAPHY AND REMOTE SENSING TO HYDROBIOLOGI-CAL RESEARCH IN SOUTH FLORIDA,

US Geological Survey. Milton C. Kolipinski, and Aaron L. Hige US Geol Surv open-file rep, 7 p, Feb 1968. 3 fig.

Descriptors: \*Remote sensing, Infrared radiation, \*Research and development, \*Aerial photography, Ions, \*Turbidity, Coastal marshes, Vegetation establishment, Aquatic plants, Gases, Water levels, Florida, Wetland, Plant groupings, Fresh water, Forestry, \*Plant ecology, Hydrologic aspects, Abiotic environment.

Identifiers: \*Photo-interpretation, \*Reflectance, \*Hydrobiological features (Methods), Stereoplotter, Salt water biota.

Recent developments in remote sensing instruments and aerial photographic techniques open broad fields in hydrological and biological studies, ecology, forestry, and agriculture. Infrared color film permits delineation of plant community types, and along coastlines and in marshes land-water interfaces are sharply portrayed. However, from low altitudes such film is inferior to standard color photography for plant taxonomic identification in Florida Everglades. False vegetation colors on infrared photos make genera and species difficult to recognize. lons and gases in water are usually not identifiable by infrared color photography. However, the presence of an identifiable indicator can serve as a concentration index of dissolved substance. Reflectances from a fresh-water vegetative community, for example, indicate water of very low chloride content. Turbidity indicators suggest low dissolved oxygen content. Data collected concurrently on ground and water are needed to supplement photography. Infrared and standard color photographs used together reinforce the skill of researchers in evaluating aquatic and biological features W68-00036

# DETERMINATION OF MOLYBDENUM IN FRESH WATERS--A COMPARISON OF METHODS.

US Geological Survey, Denver. Marvin J. Fishman, and Edward C. Mallory, Jr. J Water Pollut Contr Board, Vol 40, No. 2, Pl 1, pp R67-R71, Feb 1968, 5 p, 1 tab, 8 ref.

Descriptors: \*Analytical techniques, \*Molybdenum, \*Water quality, Metals, \*Spectrophotometry, Analytical techniques, \*Chemical analysis, \*Fresh water, \*Methodology, Technology, Laboratory tests, Water chemistry, Elements (Chemical), Spectroscopy, Trace clements. Identifiers: \*Metallic elements, Spectrographic methods \*Atomica becarring methods \*Atomica becarring methods.

Identifiers: \*Metallic elements, Spectrographic methods, \*Atomic absorption method, Dithiol method, \*Thiocyanate method.

Laboratory methods used to determine the molybdenum content of water are described and results by 4 different methods are compared. The concentrations of molybdenum in 14 fresh-water samples were determined by the thiocyanate, spectro-graphic, and dithiol-spectrophotometric methods. The dithiol-atomic absorption method was also used on 5 of the samples. Dissolved solids content of the samples ranged from 90 to 800 mg/1, and molybdenum, from 0.001 to 3.9 mg/1. The spectrographic method gave lower molybdenum values for 12 of the samples than the other methods. However, because different methods were used to concentrate the molybdenum, results are judged to be essentially comparable. Comparison of the 4 methods, and their previous successful use in analyzing highly mineralized waters, suggests that all the methods are equally applicable for analyzing any natural water. W68-00041

#### METHODS OF MEASURING WATER LEVELS IN DEEP WELLS,

US Geological Survey. M. S. Garber, and F. C. Koopman. US Geol Surv Tech Water-Resources Invest Book 8, chap Al, 23 p, 1968. 15 fig, 3 tab, 16 ref.

Descriptors: Equipment, Gages, Pressure measuring instruments, \*Water levels, \*Water level flucing instruments, \*Water levels, \*Water level fluctuations, \*Technology, Methodology, Water wells, Groundwater, \*Deep wells, Drill holes, Electrical well logging, \*Instrumentation, Calibrations, Pressure measuring instruments, \*Water table, Subsurface waters, \*Potentiometric level.

Identifiers: \*Water-level measurements, \*Measur-

ing equipment, Deep-well measurements, Steel tapes, Sensing probes, Bottom-hole recording

Accurate measurement of water levels deeper than 1,000 ft in wells requires specialized equipment and techniques. Corrections for stretch and thermal expansion of measuring tapes, periodic calibration of measuring devices, borehole deviation, and modification of recording devices are discussed in detail in this report. A multichannel recording device utilizing pressure tranducers is described and a description of its use for recording data from multi-well pumping tests is presented. Bottom-hole recording devices designed for oil-field use were tested but were found to lack the precision required for some groundwater investigations. A newly developed bottom-hole pressure gage with improved accuracy was used with satisfactory results. Applicability and the advantages and disadvantages of all the methods described are presented in tabular form. W68-00060

# FIELD TEST OF AN X-RAY SEDIMENT-CON-CENTRATION GAGE.

Agricultural' Research Service, Oxford, Miss.

Carl E. Murphree, Gerald C. Bolton, and J. Roger McHenry.

ASCE Proc, J Hydraul Div, Vol 94, No HY2, Pap 5863, pp 515-528, Mar 1968. 14 p, 4 fig, 1 tab, 6

Descriptors: \*Sediment transport, Nuclear meters, \*Testing, Clays, \*Instrumentation, Cadmium radioisotopes, X-rays, Analytical techniques, Flow graphs, Temperature, Sedimentation, Equipment, Gages.

Identifiers: \*Nuclear gage, \*Sediment concentra-tion, Sensing unit, Ambient water, Channel bed, Calibration curves, Scintillation detector.

Field tests of a suspended sediment-concentration gage are described, covering flood flows to 5,000 cfs with sediment concentrations up to 14,000 ppm. A nuclear gage, powered by storage batteries, is used with a sensing unit in the stream and a recording unit on shore. The magnitude of attenuation of x-rays, provided by a cadmium-109 source (470-day half-life), is a measure of sediment concentration. Equipment mechanism allows the beam to alternately pass through distilled water and the ambient water of the creek. Counting time is sufficient to receive a predetermined number of pulses through the distilled water reference cell. The nuclear gage is sensitive not only to suspended sediment, but also to air temperature and to instrument age. In the tests, standard deviation of the 15-min value is 200 ppm. Gage readings, corrected for age and air temperature, give sediment concentrations comparable to those determined by conventional sampling of flood waters. W68-00084

#### MEASUREMENT OF TURBULENCE

U.S. Goological Survey. Everett V. Richardson, and Raul S. McQuivery. ASCE Proc, J. Hydraul Div, Vol. 94, No. HY2, Pap 5855, pp 411-430, Mar. 1968. 19 p., 14 fig., 13 ref.

Descriptors: \*Turbulent flow, \*Hydraulics, Viscosity, Velocity, Water pollution, Temperature, Flumes, Electrolysis, Conductivity, Open channel flow, Instrumentation, Boundary layers, Reynolds numbers, Water properties, Anemometers,

measurement, Fluid mechanics, Kinetics, Hydrology, \*Turbulence. Identifiers: \*Hot-wire anemometers, \*Contaminants, Sensor, Flow field, Voltage velocity, Hydromechanics.

A study of hot-film anemometer measurements in water resulted in the hypothesis that: 'Dirt and air bubbles accumulating on the hot-film sensor change the mean voltage for a given velocity, but have only a minor, outside the frequency domain in water, effect on the frequency response of the sensor-to-velocity fluctuations. And for a given sensor there is a unique family of voltage/velocity relations that can be defined by calibration with different overheat ratios.' The hypothesis was experimentally verified by comparing turbulence measurements made in the same flow field with well filtered and with very dirty water. The method was used to measure the characteristics of turbulence measurements made in ordinary laboratory water for flow over hydraulically-rough and hydraulically-smooth boundaries. Reynolds numbers ranged from 8,000 to 20,000, and mean velocities, from 0.3 fps to 2.8 fps. Relative turbulent intensi-ties for flow over the smooth boundary were in agreement with Laufer's measurements in air. Power spectrum analysis of the turbulence showed very little energy in frequencies larger than 100 Hz. W68-00088

#### SUBMARINE SPRING DISCHARGE USING

SUBMARINE SPRING DISCHARGE USING RADIOACTIVE TRACERS,
Radiosotopes Training Center, Soug, Israel TAHAL--Consulting Engineers, Ltd., Tel Aviv.
C. J. Braudo, F. Mero, and A. Mercado.
ASCE Proc. J Hydraul Div, Vol 94, No HY2, Pap 5854, pp 399-409, Mar 1968, 11 p, 6 fig, 1 tab, 6 ref, 1 append.

Descriptors: \*Tracers, Adsorption, \*Radioactivity techniques, Cobalt, \*Lake bottom springs, Hydraulics, Boundary layers, Aquifers, Fresh water, Brackish water, Turbidity, Salinity, Temperature, Sediments, Pressure, Test procedures, Methodology, Saline water-freshwater interfaces, Environmental effects.

Identifiers: \*Submarine springs, Sea of Galilee, Jordan River, Echo sounding, Dilution cell,

Radioactivity profile.

A new method of measuring the discharge rates of submarine springs is described. The method is based on a dilution analysis of radioactive slug within a fixed volume dilution cell. Special conditions existing in a spring discharging hot and saline water through a funnel-shaped crater, on the bottom of the Sea of Galilee, provide the necessary system for dilution analysis. The experiment described requires an easily detected tracer in small concentration, owing to large masses of water and to the requirement that no change occur in physical or chemical properties of the environment. Radioactive tracer cobalt-60 (half life, 5.3 yr) was selected for this experiment after close screening. The procedure promises to yield a nearly continuous record of discharge of the spring between measuring dates with an average error between 10 and 25%. Results support the feasibility of adopting similar procedures for measuring discharge rates of numerous marine underwater springs along the continental shelves. W68-00091

USE OF AERIAL PHOTOGRAPHS IN SURVEYING GROUND-WATER AND VEGTATION RESOURCES IN THE ARID ZONE OF INDIA,

Central Arid Zone Research Institute, Jodhpur,

Y. Satyanarayan, and V. V. Dhruvanarayan. Aerial Surv and Intergated Stud, Proc of Toulouse Conf, Paris, UNESCO, pp 505-507, 1968.

Descriptors: \*Aerial photography, \*Groundwater, Irrigated land, \*Arid lands, Drainage systems, \*Mapping, Infiltration, Phreatophytes, Vegetation effects, Terrain analysis, Monsoons, Flash floods, Westership, Chamical properties.

Water table, Chemical properties.
Identifiers: India, \*Vegetation types, Brackish water, \*Photo-interpretation, \*Potential water

ource.

In the arid zone of India, estimates are made from aerial photographs of (1) the probable runoff for surfacewater storage and (2) the quality and quantity of available groundwater. This information is used in preparing maps of waterutilization areas for development. Only broad vegetation types are distinguishable from the photographs because of sparce cover and high intensity of biotic interference. As knowledge of the vegetation, habitat factors, and land forms in the photographed area increases, more reliance is placed on photo-interpretation thus reducing ground work. Assessment by the Central Arid Zone Research Institute at Jodhpur of present and potential soil, vegetation, and water resources for efficient utilization has been under way since 1960. W68-00092

## 9B. Education (In-House)

VELOCITY AND SEDIMENT CONCENTRATION DISTRIBUTIONS IN OPEN CHANNEL FLOWS, South Dakota State Univ., Brookings.

B. F. F. Fro.

Descriptors: \*Open channel flow, Flow Characteristics, Flow profiles, \*Velocity, Transition flow, Turbulent flow, Theoretical analysis, Sediment transport, \*Sediment distribution, Instrumentation, Continuity equation, Momentum equation, \*Channel morphology, Boundary layer, Roughness coefficient.

Turbulent velocity distributions in open channel flows were analytically reviewed and experimentally investigated, the works of Prandtl, Von Karman, and Nikuradse pertaining to turbulent velocity distributions were critically reviewed with a view toward particular application to open channel flows. Physical and mathematical inadequacies of these works were noted and discussed. The experimental phase consisted of velocity distribution measurement in smooth and artifically rough channels. The roughness elements included lateral strips, cubes and hemispheres placed on the flume bed at various spacings in various patterns. An equivalent roughness parameter was devised and calculated for many of the roughness patterns. The experimental results were compared to the work of other authors and discussed. The suspended sediment transport theory was briefly reviewed, emphasizing its dependency upon a valid velocity distribution model. W68-00185

# 08. ENGINEERING WORKS

# 8B. Hydraulics

MIXING OF TWO CONCENTRIC JETS, Indian Institute of Technology, Bombay. D. C. Kotwal, Y. R. Reddy, and Subir Kar. ASCE Proc, J Hydraul Div, Vol 94, No HY2, Pap 5866, pp 505-514, Mar 1968. 15 p, 4 fig, 20 ref.

Descriptors: \*Hydraulics, Turbulence, Engineering, Reynolds number, \*Energy losses, \*Jets, Fluid mechanics, Velocity, Equations, Streams, Flow characteristics, Centrifugal pumps, Orifices, Nozzles, Pressure, Mass transfer, \*Mixing-Identifiers: \*Coaxial streams, Shear losses, Optimum efficiency, Turbulent diffusion, Hydraulic jets.

A theoretical equation is given for estimating the mixing loss co-efficient when mixing two concentric jets. The equation has been experimentally verified with water as the working fluid. In the experiments, two outer nozzles of semicone angles of 12 deg and 24 deg were used for different velocity ratios varying from 0.00824 to 0.792. The mixing loss constant reduces with increase in velocity ratio to unity, beyond which it increases with increase in velocity ratio for a given area ratio and angle. The mixing loss constant increases with nozzle angle when all other parameters are constant. For a particular mixing configuration the mixing efficiency increases with nozzle distance and reaches an optimum value; with further increase of nozzle distance distance for mixing on the order of 98% was obtained at a velocity ratio of 0.642 for a nozzle semicone angle of 24 deg at a nozzle distance of 7.9 cm.

HYDRAULIC JUMPS BELOW ABRUPT SYMMETRICAL EXPANSIONS,

Alberta University, Edmonton. Nallanuthu Rajaratnam, and Kanakatti Subramanya

ASCE Proc, J Hydraul Div, Vol 94, No HY2, Pap 5860, Mar 1968. 23 p, 22 fig, 2 tab, 12 ref.

Descriptors: \*Channels, \*Hydraulic jump, Bed load, Waves (Water), Open-channel flow, Tailwater, Hydrodynamics, Supercritical flow, Boundaries (Surfaces), Shear stress, Flow characteristics, \*Hydraulics, Outlets, Momentum equation, Energy dissipation, Turbulence. Identifiers: \*Symmetrical expansion, \*Unstable flow, Wall jet, Channel geometry, R-jump, S-jump, Bed pressure, Sequent depth.

An experimental study is described of the R-jump and S-jump that occur below abrupt symmetrical expansions in rectangular channels. The tailwater depth-range between these jumps causes unstable and undesirable flow conditions. An empirical equation to predict the sequent depth is developed, and length characteristics of R-jumps are determined. A simple formula is presented for the sequent depth of S-jumps. Results have been obtained of energy loss in S-jump, and a new characteristic length is developed to correlate mean flow characteristics of the S-jump. The S-jump is treated as a diffusion problem of a rectangular wall jet in a wider channel under adverse pressure gradient.

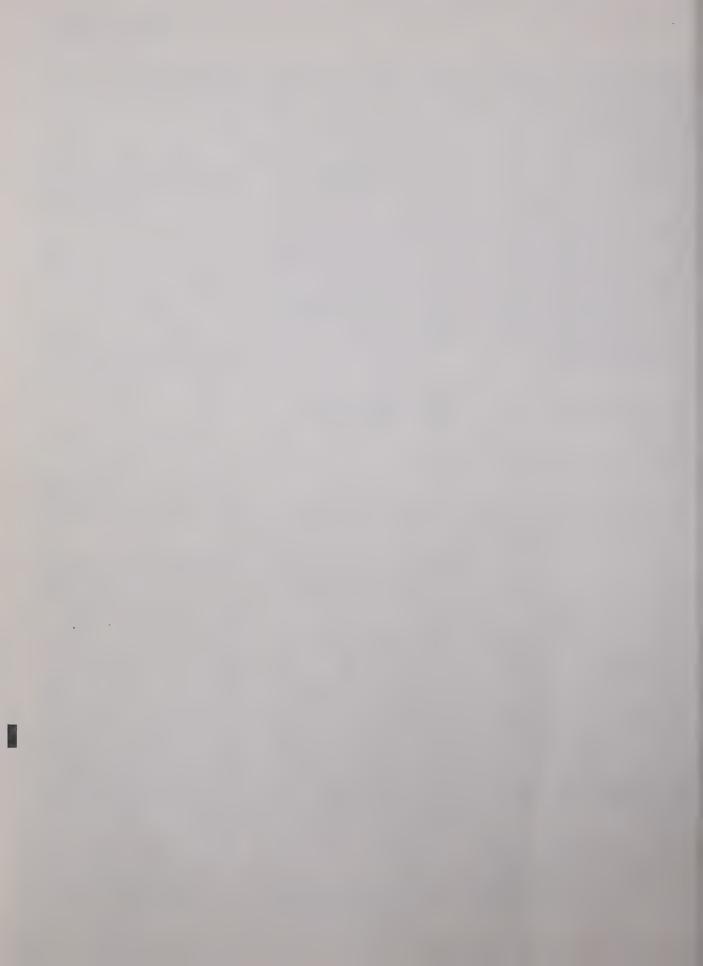
FREE SURFACE SHEAR FLOW OVER A WAVY BED,

Massachusetts Institute of Technology, Cambridge. Iwasa Yoshiaki, and John F. Kennedy. ASCE Proc, J Hydraul Div, Vol 94, No HY2, Pap 5856, pp 431-454, Mar 1968. 24 p, 6 fig, 2 tab, 18

Descriptors: \*Hydraulics, \*Flow, \*Boundaries (Surfaces), Energy dissipation, Alluvial channels, Waves (Water), Open channel flow, Hydraulic jump, Mechanical properties, Fluid mechanics, Velocity, Steady flow, Supercritical flow, Hydrodynamics, Pressure head, Flumes, Froude number, Scour, Energy equation, Non-uniform

Identifiers: \*Shear flow, Channel waves, Bi-stable, \*Wavy bed, Bed forms, Phase shift, Surface profile.

An analytical treatment of free surface shear flow, over a wavy bed of regular sinusoidal form, is developed from the one-dimensional energy equation. The effects of curvilinearity on the velocity and piezometric heads are examined. The equation is expanded into a series in dimensionless terms for systematic ordering of the magnitudes of various terms and associated physical quantities. The third-order equation is linearized and solved to obtain expressions for the phase shift between, and amplitude ratio of the bed waves and depth variations. The second-order, nonlinear equation is solved numerically for a particular flow, and the profiles are presented graphically. The various flow configurations predicted by the linearized and the nonlinear formulations are discussed, and the occurrence of a bistable flow of moderate and high Froude numbers is explained.



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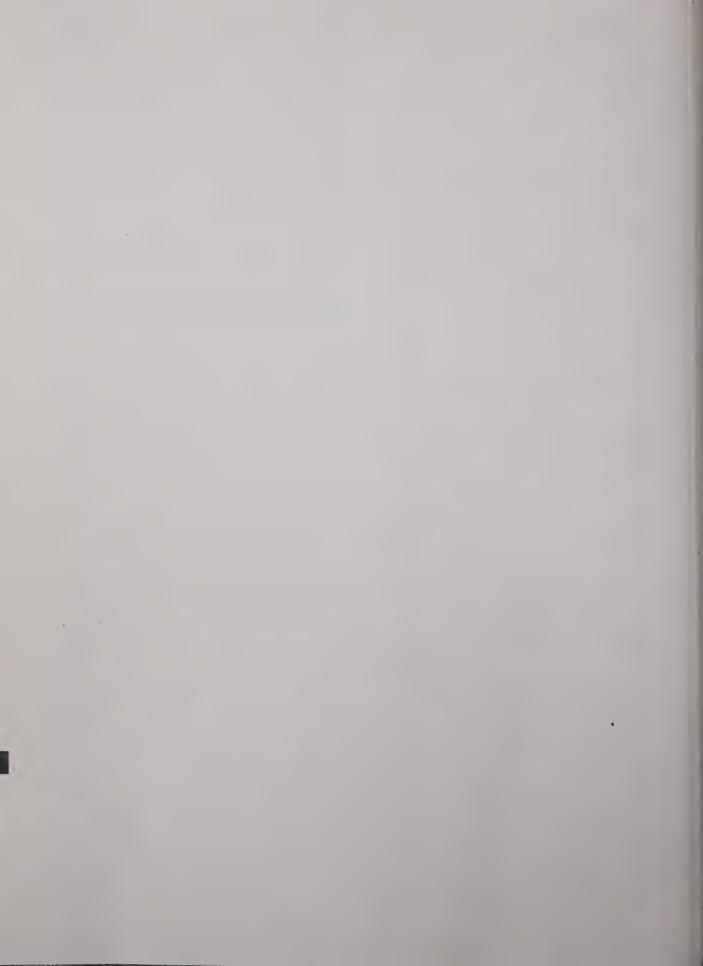
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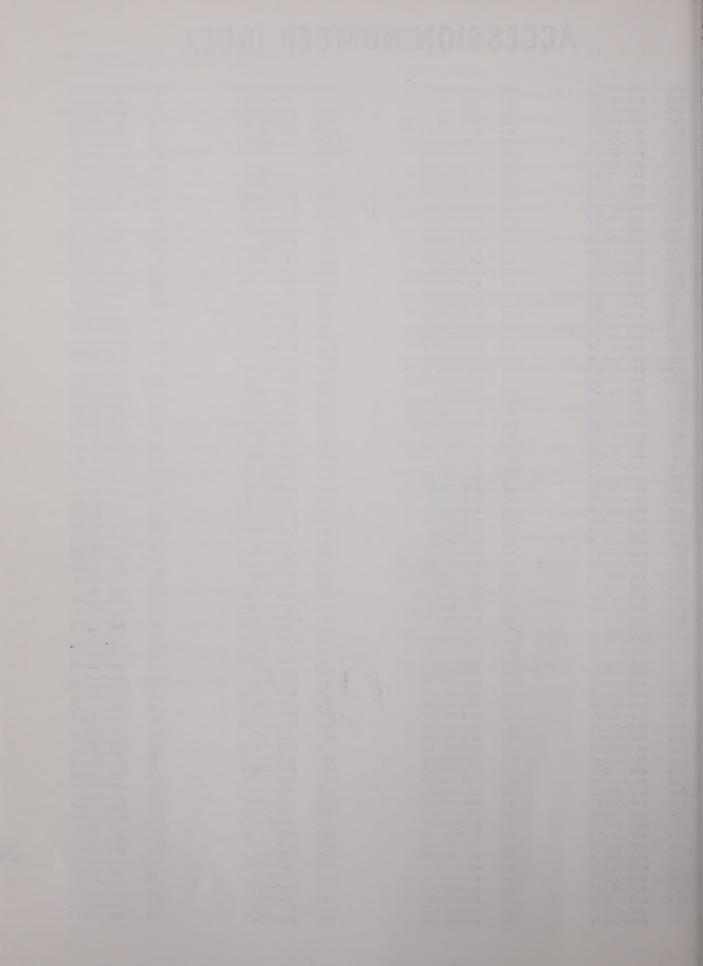
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03B			W68-00119		06B	W68-00197	03B	W68-00274
07B	W68-00041	050				W68-00198	03F	W68-00275
04A	W68-00042	06D	W68-00120		06E		03B	W68-00276
060	W68-00043	06E	W68-00121		06B	W68-00199	03F	W68-00277
06B	W68-00044	05G	W68-00122		05G	W68-00200		W68-00278
04A	W68-00045	05F	W68-00123		06E	W68-00201	04D	
06B	W68-00046	06D	W68-00124		06B	W68-00202	04D	W68-00279
		06B	W68-00125		05E	W68-00203	07A	W68-00280
02E	W68-00047				06B	W68-00204	021	W68-00281
04A	W68-00048	06E	W68-00126				04B	W68-00282
03B	W68-00049	06C	W68-00127		06B	W68-00205	03F	W68-00283
03B	W68-00050	06D	W68-00128		06E	W68-00206	021	W68-00284
02E	W68-00051	06B	W68-00129		06E	W68-00207		W68-00285
05B	W68-00052	06F	W68-00130		05G	W68-00208	03B	
	W68-00053	060	W68-00131		06E	W68-00209	06D	W68-00286
04A		06B	W68-00132		06E	W68-00210	03B	W68-00287
05G	W68-00054				06D	W68-00211	04D	W68-00288
05F	W68-00055	06E	W68-00133		0.5	W68-00212	02J	W68-00289
04B	W68-00056	06B	W68-00134		06E	W68-00213	03F	W68-00290
05G	W68-00057	06E	W68-00135		04D	W68-00213	03C	W68-00291
05A	W68-00058	06A	W68-00136		05G	W68-00214	03F	W68-00292
04B	W68-00059	05D	W68-00137		05C	W68-00215		W68-00293
07B	W68-00060	06C	W68-00138		06E	W68-00216	03F	
		06E	W68-00139		06E	W68-00217	02F	W68-00294
04A	W68-00061				05G	W68-00218	02G	W68-00295
03B	W68-00062	06E	W68-00140			W68-00219	04B	W68-00296
03B	W68-00063	06E	W68-00141		05G	W68-00220	02B	W68-00297
03B	W68-00064	05G	W68-00142		05B			W68-00298
03B	W68-00065	06E	W68-00143		06D	W68-00221	06G	W68-00299
04B	W68-00066	06E	W68-00144		06E	W68-00222	02K	
	W68-00067	06E	W68-00145		06A	W68-00223	03B	W68-00300
04D			W68-00146		06B	W68-00224	04B	W68-00301
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04B	W68-00070	04A	W68-00148		04B		04A	W68-00304
04A	W68-00071	06E	W68-00149		06D	W68-00227	02E	W68-00305
03B	W68-00072	05G	W68-00150		060	W68-00228		
04B	W68-00073	06E	W68-00151		06B	W68-00229	060	W68-00306
		06E	W68-00152		06E	W68-00230	02B	W68-00307
04D	W68-00074		W68-00153		06E	W68-00231	06B	W68-00308
02E	W68-00075	05G			04A	W68-00232	02G	W68-00309
06A	W68-00076	05G	W68-00154			W68-00233	02J	W68-00310
04B	W68-00077	06E	W68-00155		060		03B	W68-00311
03A	W68-00078	06E	W68-00156		06E	W68-00234	7,50	
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